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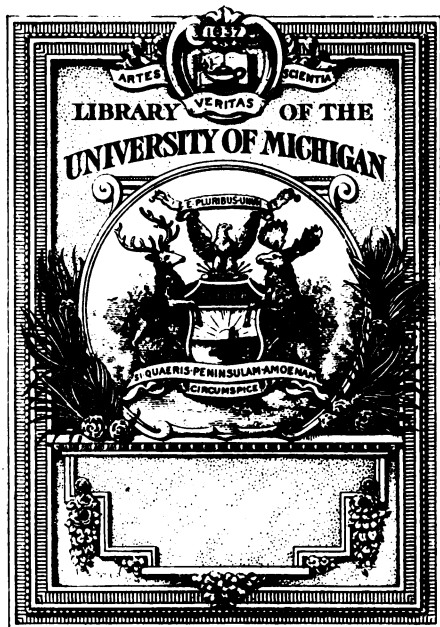
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CHEMICAL PROBLEMS.

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Authorized Translations by

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Laboratories of the University of Pennsylvania and Muhlenberg Col-
lege; Member of the Chemical Societies of Berlin and
Paris, of the Academy of Natural Sciences
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CHEMICAL PROBLEMS.

BY

DR. KARL STAMMER.

TRANSLATED FROM THE SECOND GERMAN EDITION,
WITH EXPLANATIONS AND ANSWERS,

BY

W. S. HOSKINSON, A.M.,

WITTENBERG COLLEGE, SPRINGFIELD, O.

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CONTENTS.

PART FIRST.

	PAGE
I. OXYGEN.....	9
II. HYDROGEN.....	13
III. CHLORINE.....	16
IV. NITROGEN.....	19
V. SULPHUR.....	23
VI. PHOSPHORUS.....	28
VII. CARBON.....	29
VIII. FLUORINE.....	33
IX. POTASSIUM.....	34
X. SODIUM.....	37
XI. AMMONIUM.....	40
XII. BARIUM.....	41
XIII. CALCIUM.....	42
XIV. MAGNESIUM.....	44
XV. ALUMINIUM.....	45
XVI. IRON.....	45
XVII. MANGANESE.....	48
XVIII. CHROMIUM.....	49
XIX. ZINC.....	50
XX. COPPER.....	51

	PAGE
XXI. MERCURY.....	54
XXII. LEAD.....	56
XXIII. SILVER.....	57
XXIV. TIN.....	59
XXV. ANTIMONY.....	60
XXVI. ARSENIC.....	61
XXVII. PLATINUM.....	62

PART SECOND.

XXVIII. APPROXIMATE RATIOS..	63
XXIX. TEMPERATURE AND ATMOSPHERIC PRESSURE.....	64
XXX. MIXED PROBLEMS.....	65
ANSWERS TO PROBLEMS.....	83

ATOMIC WEIGHTS.

Aluminium.....	Al	27.4	Iodine.....	I	127
Antimony.....	Sb	122	Lead.....	Pb	207
Arsenic.....	As	75	Magnesium.....	Mg	24
Barium.....	Ba	137	Manganese.....	Mn	55
Bismuth.....	Bi	208	Mercury.....	Hg	200
Boron.....	B	11	Nitrogen.....	N	14
Bromine.....	Br	80	Oxygen.....	O	16
Cadmium.....	Cd	112	Phosphorus.....	P	31
Calcium.....	Ca	40	Platinum.....	Pt	198
Chlorine.....	Cl	35.5	Potassium.....	K	39
Chromium.....	Cr	52	Sulphur.....	S	32
Copper.....	Cu	63.4	Silver.....	Ag	108
Carbon.....	C	12	Silicon.....	Si	28
Fluorine.....	Fl	19	Strontium.....	Sr	88
Gold.....	Au	197	Sodium.....	Na	23
Hydrogen.....	H	1	Tin.....	Sn	118
Iron.....	Fe	56	Zinc.....	Zn	65

CHEMICAL PROBLEMS.

PART FIRST.

I.—OXYGEN.

1. How much oxygen can be obtained by heating 216 g mercuric oxide?
2. How much oxygen can be obtained by heating mercuric oxide as follows:—

- a.* 108 g, *c.* 5.4 Kg, *e.* 1.08 g?
b. 54 g, *d.* 1 Kg 80 g,

Solution: 216 parts oxide produce 16 parts oxygen.
 108 g produce the half, or 8 g, etc.

3. How much oxygen can be obtained by heat from 20 g mercuric oxide?

Solution: 216 parts oxide give 16 parts oxygen.

1 part " gives $\frac{16}{216}$ " "
 20 g " give $20 \times \frac{16}{216} = 1.48$ g.

Or thus: $\frac{?}{216} \mid \frac{20}{16}$ etc.

4. How much oxygen is obtained from 1 Kg mercuric oxide?
5. How much oxygen will be obtained from—
a. 67½ g, *b.* 675 g, *c.* 337.5 g?
6. What amount of oxygen can be obtained by heat from potassium chlorate, as follows:—

- a.* 245 g, *c.* 367.5 g, *e.* 0.245 Kg?
b. 122.5 g, *d.* 2.45 g,

Solution: $\text{K}_2\text{O}, \text{Cl}_2\text{O}_8 = 2 \text{KCl} + 6 \text{O}$.

($\text{KClO}_3 = \text{KCl} + 3 \text{O}$.)

$\left. \begin{array}{l} \text{K}_2 \ 78 \\ \text{Cl}_2 \ 71 \\ \text{O}_6 \ 96 \end{array} \right\} 245 \text{ parts furnish } 96 \text{ parts oxygen, etc.}$

(Or: 122.5 parts furnish 48, etc.)

7. By this operation how much mercury is left from 1 to 5?
8. How much potassium chloride is obtained by 6?
9. How much oxygen is obtained by heat from 10 g potassium chlorate?

Solution: One molecule by weight, or 245 parts, give 6 combined weight or 96 parts. (Or: 122.5 parts give 48, etc.)
 1 part by weight gives also $\frac{96}{245}$ parts; and 10 g $\frac{10 \times 96}{245}$ g.

Or: How many give 10 g, when 245 g give 96 g?

Thus: $\begin{array}{r|l} ? & 10 \\ 245 & 96 \end{array}$ etc.

10. What per cent. of oxygen is obtained from a given weight of potassium chlorate?
11. How much oxygen is contained in, *a.* 1 Kg, *b.* $2\frac{3}{4}$ Kg of potassium chlorate?
12. How much oxygen is obtained from potassium chlorate as follows:—
a. 2.5521 g, *b.* 81.8 g, *c.* 1 g?
13. How much potassium chloride remains in these cases?
14. How many grams and kilograms of oxygen are contained in black oxide of manganese as follows:—
a. 87 g, *c.* 870 g, *e.* 217.5 g?
b. 8.7 Kg, *d.* 21.75 Kg,
15. How many lbs. of oxygen are contained in, *a.* 100 Kg, *b.* 1 lb. black oxide of manganese?
16. How much of the oxygen contained in 87 g of black oxide of manganese will be set free by sulphuric acid?
17. *a.* What quantity of the oxygen contained in 100 Kg of manganese di-oxide will be obtained by heating the same with sulphuric acid? *b.* How much of that contained in one lb?
18. How many kilograms of oxygen are obtained, by means of sulphuric acid, from manganese di-oxide, as follows:—
a. 1 cwt., *b.* 10 Kg, *c.* 29 g?

19. *a.* How much oxygen can be obtained by heating 261 g of black oxide of manganese?

Solution: $3 \text{ Mn O}_2 = \text{Mn}_3 \text{ O}_6 = \text{Mn}_3 \text{ O}_4 + 2 \text{ O}$.

Or: 261 parts by weight give 32 parts by weight.

How much from,—

- | | | |
|--------------------|--------------------|-------------------|
| <i>b.</i> 130.5 g, | <i>d.</i> 26.1 Kg, | |
| <i>c.</i> 1.305 g, | <i>e.</i> 32.6 g, | <i>f.</i> 522 Kg? |
20. How much is obtained by heating the specified quantities in examples 16, 17, 18?
21. What per cent. of the oxygen contained in black oxide of manganese is obtained, *a.* by sulphuric acid; *b.* by heat? *c.* What per cent. more by first?
22. If the quantity of oxygen be given which is contained in a given quantity of manganese, how does one find that which is actually set free?
23. How much sulphuric acid is needed in order to decompose 87 g of black oxide of manganese?
24. How much oxygen and manganous sulphate are obtained?
25. How much sulphuric acid is needed to decompose the following quantities of manganese di-oxide:—
- | | |
|--------------------|--------------------|
| <i>a.</i> 43.5 Kg, | <i>c.</i> 1 cwt., |
| <i>b.</i> 6.2 g, | <i>d.</i> 10 lbs.? |
26. How much manganous sulphate is obtained by 25 *a* to *d*?
27. How much mercuric oxide is required to yield oxygen as follows:—
- | | | |
|-----------------|-----------------|----------------|
| <i>a.</i> 16 g, | <i>c.</i> 24 g, | <i>e.</i> 4 g? |
| <i>b.</i> 32 g, | <i>d.</i> 8 g, | |
28. How much mercuric oxide is necessary to yield the following amounts of oxygen:—
- | | | |
|-----------------|-----------------|---------------------|
| <i>a.</i> 1 Kg, | <i>c.</i> 5 g, | <i>e.</i> 1.4336 g? |
| <i>b.</i> 2 g, | <i>d.</i> 10 g, | |
29. How would you find simply the necessary quantity of mercuric oxide for a given quantity of oxygen?

30. How much potassium chlorate is necessary to obtain oxygen as follows :—

a. 96 g, *c.* 144 Kg, *e.* 96 g?
b. 48 g, *d.* 0.96 g,

31. How much potassium chlorate is necessary to yield oxygen as follows :—

a. 1 g, *c.* 3.919 g, *e.* 1.4336 g?
b. 1 Kg, *d.* 0.3919 g,

32. How much manganese di-oxide is needed to yield, by heat, 16 Kg of oxygen?

Solution : 3 MnO_2 or 216 parts by weight give 2 O or 32 parts by weight. Thus, 32 Kg are obtained from 216 Kg; or, 16 Kg from 130.5 Kg.

33. How much manganese di-oxide is required to yield, by heat, oxygen as follows :—

a. 4 g, *b.* 0.16 g, *c.* 3.2 Kg?

34. How much to yield—

a. 10.6667 Kg, *c.* 0.1226 g, *e.* 1.226 Kg,
b. 12.26 Kg, *d.* 6.13 Kg, *f.* 3.55 g?

35. How much manganese di-oxide is needed to yield oxygen by means of sulphuric acid, as follows :—

a. 16 g, *b.* 8 g, *c.* 4 Kg, *d.* 0.4 lbs.?

36. How much by the same for—

a. 9.2 Kg, *c.* 5.33 g, *e.* 0.184 g,
b. 1.84 Kg, *d.* 18.4 g, *f.* 100 g?

37. How much sulphuric acid is used in all these cases?

38. How much manganese di-oxide and sulphuric acid are needed to yield oxygen as follows :—

a. 16 g, *c.* 100 g, *e.* 1.4336 g?
b. 20 lbs., *d.* 1 Kg,

Solution : It is necessary, in the first place, to reckon the quantity of manganese di-oxide, and then the necessary quantity of oxygen for the decomposition of the same.

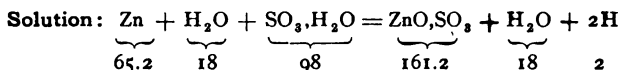
The following problems, relating to definite volume ratios, are most practicably considered after solving those under II.

39. How much mercuric oxide is necessary to yield 1 cu dm of oxygen?
40. How much mercuric oxide is necessary to yield 1.5 cu m of oxygen?
41. How many cubic meters of oxygen will the following quantities of potassium chlorate furnish:—
a. 1 cwt., *b.* 10 Kg, *c.* 3.659 g?
42. How much manganese di-oxide and sulphuric acid are necessary to give 1 cu dm of oxygen?
-

II.—HYDROGEN.

1. How much *a.* hydrogen, *b.* oxygen, are contained in 18 Kg of water?
2. How much hydrogen and oxygen are contained by weight in water as follows:—
a. 9 Kg, *d.* 9000 g, *g.* 18 cu cm,
b. 36 g, *e.* 81 Kg, *h.* 9 l?
c. 27 g, *f.* 0.18 g,
3. How much hydrogen and oxygen by weight can be obtained from water, by the use of the galvanic current, as follows:—
a. 1 Kg, *c.* 1000 cu cm,
b. 50 g, *d.* 0.25 l?
4. How much hydrogen is obtained, by passing the vapor from water over iron, as follows:—
a. 18 g, *c.* 0.1 Kg, *e.* 300 cu cm,
b. 30 g, *d.* 10 cu cm, *f.* 1 l?
5. About how much heavier will the tube with the iron be at this time?
6. What is the percentage composition of water?
7. How, in general, do we ascertain the quantity of hydrogen set free from a given quantity of water by

- any method, and also the quantity of oxygen that at the same time enters combination?
8. How much hydrogen is obtained by the use of 98 g of sulphuric acid and 65.2 g of zinc?
 9. How much hydrogen is obtained from—
 - a.* 49 Kg of sulphuric acid and 32.6 Kg of zinc,
 - b.* 100 g “ “ 66.5 g “ ?
 10. Is it necessary that the quantities of both substances be given, or is the quantity of one of them dependent upon the other? What occurs if, for example, 100 g of zinc act upon 100 g of sulphuric acid?
 11. How much hydrogen can be obtained by means of 7 Kg of sulphuric acid applied to zinc or iron?
 12. How much hydrogen does a sufficient quantity of water and zinc give when 12.74 g of sulphuric acid are used?
 13. How much hydrogen can be obtained by the use of zinc without water, and sulphuric acid as follows:—
 - a.* 179.3 g, *c.* 217.116 Kg,
 - b.* 299.2 g, *d.* 26.08 Kg?
 14. How many liters of hydrogen will the following amounts of water furnish:—
 - a.* 0.8064 g, *b.* 80.64 g, *c.* 1 Kg?
 15. How many liters of oxy-hydrogen gas will 1 l of water give?
 16. How many liters of explosive gas will 1 cu cm of water furnish?
 17. How many cubic centimeters of oxy-hydrogen gas will yield 1000 cu cm of steam at 0° and 760 mm pressure? How is the former volume related to the latter?
 18. How much sulphuric acid is necessary to liberate the hydrogen from 18 Kg of water? How much zinc?
 19. What amounts of sulphuric acid and zinc are required for the decomposition of 15 g of water?



(Or, $\text{Zn} + \text{H}_2\text{O} + \text{H}_2\text{SO}_4 = \text{ZnSO}_4 + \text{H}_2\text{O} + 2\text{H}$.)

For 18 parts by weight it is necessary to have 98 of sulphuric acid to 65.2 Zn.

For 1 part $\frac{98}{18}$ of sulphuric acid and $\frac{65.2}{18}$ zinc.

For 15 parts $\frac{98 \times 15}{18}$ sulphuric acid and $\frac{65.2 \times 15}{18}$ zinc, etc.

Or thus: $\frac{?}{18} \mid \frac{15}{98}$ etc. $\frac{?}{18} \mid \frac{15}{65.2}$ etc.

20. How much sulphuric acid and zinc are needed for the given quantities of water in No. 14 above?
21. How much lighter must the weight of the retort become, which holds the water whose vapor, by coming in contact with heated iron, yields hydrogen as follows:—

<i>a.</i> 3 g,	<i>c.</i> 4.5 g,	<i>e.</i> 8.96 g?
<i>b.</i> 90 g,	<i>d.</i> 10 g,	
22. About how much heavier will the tube become thereby?
23. What amount of sulphuric acid and zinc are required to yield hydrogen as follows:—

<i>a.</i> 2 Kg,	<i>c.</i> 0.0896 g,
<i>b.</i> 100 g,	<i>d.</i> 89.6 g?
24. How much water must be decomposed to yield hydrogen as follows:—

<i>a.</i> 1000 cu cm,	<i>c.</i> 1000 Hl (Ans. in Kilos)?
<i>b.</i> 100 l (Ans. in liters),	
25. What amount of sulphuric acid and zinc is necessary to obtain the same quantities? (Ans. in g and K).

III.—CHLORINE.

1. How much chlorine can be obtained from the following amounts of hydrochloric acid (gas) by means of manganese di-oxide :—

<i>a.</i> 146 Kg,	<i>b.</i> 146 lbs.,	<i>c.</i> 146 g?
-------------------	---------------------	------------------
2. What quantity of chlorine is evolved by the union of the following amounts of muriatic acid and an indefinite amount of manganese di-oxide :—

<i>a.</i> 73 g,	<i>b.</i> 7 Kg 300 g,	<i>c.</i> 7.3 g?
-----------------	-----------------------	------------------
3. How much Cl are, *a.* 87 g, *b.* 0.87 Kg, *c.* 100 lbs., *d.* 20 g, of black oxide of Mn. able to liberate from HCl?
4. How many cubic decimeters of chlorine can be obtained from, *a.* 100 g of manganese di-oxide; *b.* 100 g of muriatic acid?
5. How much muriatic acid is required for manganese di-oxide as follows :—

<i>a.</i> 87 lbs.,	<i>c.</i> 100 g,
<i>b.</i> 43.5 g,	<i>d.</i> 1 Kg?
6. What amount of manganese di-oxide must be taken with the following quantities of hydrochloric acid to yield chlorine, if all of both substances be decomposed :—

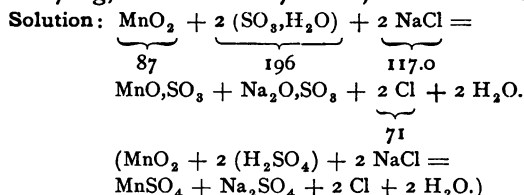
<i>a.</i> 146 g,	<i>d.</i> 10 lbs.,
<i>b.</i> 1 Kg 460 g,	<i>e.</i> 16.78 g,
<i>c.</i> 1 lb.,	<i>f.</i> 1678.17 g?
7. How much black oxide of manganese and muriatic acid are necessary to yield chlorine as follows :—

<i>a.</i> 71 g,	<i>d.</i> 40.804 Kg,
<i>b.</i> 35.5 lbs.,	<i>e.</i> 81.61 g,
<i>c.</i> 7.1 g,	<i>f.</i> 48.63 g?
8. What amounts of manganese di-oxide and hydrochloric acid are needed to make chlorine as follows :—

<i>a.</i> 128.30 cu dm,	<i>b.</i> 152.9 cu dm,	<i>c.</i> 1 cu m?
-------------------------	------------------------	-------------------

9. How much sulphuric acid, common salt, and manganese di-oxide are necessary to give the following amounts of chlorine:—

a. 71 g, *b.* 7.1 lbs., *c.* 100 g?



10. How much sulphuric acid, common salt, and manganese di-oxide must be taken to give the following amounts of chlorine:—

a. 100 l, *b.* 1 cu m?

11. How many grams of chlorine will be absorbed by 10 l of water, if the water takes up twice its volume?
12. In what proportion will the water become heavier if it takes up twice its volume of chlorine?
13. How many cubic centimeters of chlorine are contained in 100 g of chlorine water, if one volume of water has absorbed two volumes of chlorine?

HYDROCHLORIC ACID.

14. How much hydrochloric acid gas is obtained from common salt as follows:—

a. 117 lbs., *d.* 100 lbs.,
b. 58.5 Kg, *e.* 1000 g,
c. 11.7 g, *f.* 1 g?

15. How much hydrochloric acid gas may be obtained from an indefinite quantity of common salt by means of sulphuric acid as follows:—

a. 98 lbs., *d.* 1 g,
b. 49 g, *e.* 250 g,
c. 4.9 g, *f.* 100 Kg?

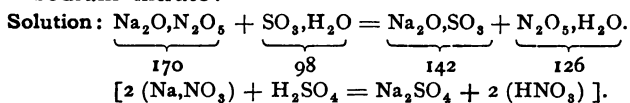
16. How much sulphate of soda remains behind in these cases?
17. What amount of common salt is necessary to obtain all the chlorine in the shape of hydrochloric acid gas by means of sulphuric acid as follows:—
- | | |
|--------------------|---------------------|
| <i>a.</i> 98 g, | <i>d.</i> 110 lbs., |
| <i>b.</i> 49 lbs., | <i>e.</i> 1000 g, |
| <i>c.</i> 0.7 g, | <i>f.</i> 25 g? |
18. What quantity of sulphuric acid and common salt must be taken to yield the following amounts of hydrochloric acid gas:—
- | | |
|--------------------|------------------|
| <i>a.</i> 73 lbs., | <i>c.</i> 1 Kg, |
| <i>b.</i> 36.5 g, | <i>d.</i> 100 g? |
19. By their union, one volume of hydrogen and one volume of chlorine yield 2 volumes of hydrochloric acid gas. What, therefore, is the volume by weight of the latter referred to hydrogen as unit? How much is contained in the liter?
20. How much sulphuric acid and common salt are necessary to yield 1 cu m of hydrochloric acid gas?
21. What amount of sulphuric acid and common salt must be mixed, and how much water is used, to obtain the following amounts of aqueous gas, 30 per cent. of the contents of which is pure acid:—
- | | | |
|-----------------------------------|-----------------------|-------------------|
| <i>a.</i> 233 $\frac{1}{3}$ lbs., | <i>b.</i> 4666.667 g, | <i>c.</i> 700 Kg? |
|-----------------------------------|-----------------------|-------------------|
- How much sodium sulphate is produced?
- Solution:** First reckon how much anhydrous hydrochloric acid gas is wanted; from this find the individual substances.
22. What per cent. of its weight of hydrochloric acid gas does water contain, which has absorbed 400 times its volume of this gas?
23. What per cent. of hydrochloric acid gas does the liquid contain, when one liter of water has absorbed 50 l of the gas?
24. How many cubic centimeters of hydrochloric acid gas does 1 g of aqueous acid contain which corresponds to the formula $\text{HCl} + 5 \text{H}_2\text{O}$?

IV.—NITROGEN.

1. If the spec. grav. by weight of air amounts to $\frac{1}{79}$ in relation to water, how great is the same in relation to hydrogen?
2. What does 1 cu m of air weigh at 0° and 760 mm pressure?
3. How much is the spec. grav. by weight of air in relation to water; how much is that of water in relation to air as unit?
4. What is the volume-weight of air referred to oxygen as unit? What, referred to nitrogen as unit?
5. If it be granted that air consists of 79 volumes of nitrogen and 21 oxygen, how many times heavier is one volume of air than an equal volume of hydrogen?
6. Compute from the data in the preceding examples the percentage composition of air. (Spec. grav. of nitrogen = 14.)
7. Required 1 cu m of nitrogen. How much air is to be deprived of oxygen, and how much phosphorus must be burned (composition of air as in Ex. 5), if 62 parts of phosphorus unite with 80 parts of oxygen?

NITRIC ACID.

8. How much nitric acid is obtained from 170 g of sodium nitrate?



9. How much nitric acid ($\text{N}_2\text{O}_5, \text{H}_2\text{O}$) is obtained from the following amounts of sodium nitrate:—

<i>a.</i> 85 lbs.,	<i>d.</i> 8.517 g,
<i>b.</i> 17 g,	<i>e.</i> 1 Kg 700 g,
<i>c.</i> 1 Kg,	<i>f.</i> 8.5 g?
10. What per cent. of water does this nitric acid contain?

11. How much anhydrous acid do the quantities in the foregoing examples contain?
12. How much water must be taken in every case in order that the acid may contain 40 per cent. water?
13. How much nitric acid containing 46 per cent. of its amount of water may be obtained from 1700 g of sodium nitrate, and how much water must be taken?
14. What amount of sulphuric acid is needed to decompose the following quantities of sodium nitrate:—

- a.* 170 Kg, *c.* 8.5 g, *e.* 1 Kg,
b. 85 lbs., *d.* 20 g, *f.* 12 g?

Solution: $\underbrace{\text{Na}_2\text{O}, \text{N}_2\text{O}_5}_{170} + \underbrace{\text{SO}_3, \text{H}_2\text{O}}_{98} = \text{etc.}$

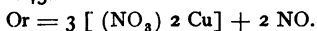
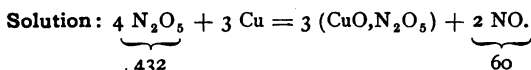
$(2 \text{ NaNO}_3 + \text{H}_2\text{SO}_4 = \text{etc.})$
 For 170 parts 98 are needed.

" 1 part $\frac{98}{170}$ "
 " 20 parts $\frac{20 \times 98}{170}$ are needed, etc.

15. How much sodium nitrate and sulphuric acid would be required to yield nitric acid as follows:—
a. 126 g, *c.* 25.2 g, *e.* 100 g, *g.* 1 Kg,
b. 63 lbs., *d.* 6.3126 g, *f.* 110 lbs., *h.* 700 g?
16. What quantity of nitrate of soda and sulphuric acid are required, and how much water must be taken in order to obtain the following amounts of acid with 40 per cent. of the water:—
a. 450 lbs., *b.* 1 Kg 800 g?

Solution: First reckon the quantity of anhydrous acid contained in the required amount of acid, then the amount of both substances necessary for it, and from the water belonging to it deduct the quantity already contained in it as hydrate.

17. How much nitric oxide may be obtained from the following amounts of anhydrous nitric acid:—
a. 432 lbs., *c.* 1 lb., *e.* 6 g?
b. 216 g, *d.* 2.84 g,



18. How much nitric acid may be obtained from the produced nitric oxide by mixing with air, if it be granted that only nitrous acid is formed?
19. What amount of nitric oxide and nitrous acid (by the same conditions as 18) may be obtained from the following quantities of nitric acid containing 75 per cent. of anhydrous acid :—
 - a.* 72 lbs., *b.* 2 Kg, *c.* 5 g?
20. About how much heavier will any quantity of water become when the following amounts of nitrous acid have passed through it :—
 - a.* 228 g, *b.* 57 g, *c.* 4 g?

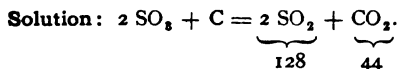
AMMONIA.

21. What is the percentage composition of ammonia?
22. What is the percentage composition of sal-ammoniac?
23. How much does one liter of ammonia gas weigh?
24. What is the spec. grav. of ammonia when referred to air as unit? What, referred to water?
25. How many grams of ammonia gas will be absorbed by 5 liters of water, if it be granted that it takes up 500 times its volume? In what proportion will the weight of the water be increased by this operation?
26. How much ammonia will the following quantities of sal-ammoniac furnish :—
 - a.* 53.5 g, *b.* 535 lbs., *c.* 1 lb., *d.* 1000 g?
27. How much ammonia may be obtained from 56 g of burnt lime and 107 g of sal-ammoniac? Must the quantities of both materials be given, or is one conditioned by the other, and does the amount of lime given suffice for the calculation of the ammonia?

28. What amount of ammonia can be made from the following quantities of burnt lime by means of sal-ammoniac :—
a. 28 g, *b.* 7 lbs., *c.* 1 lb., *d.* 1000 g?
29. How much calcium chloride would be obtained in these cases?
30. How much burnt lime is needed to yield sal-ammoniac as follows :—
a. 107 g, *b.* 53.5 lbs., *c.* 1 lb., *d.* 1 Kg?
31. How much sal-ammoniac can be decomposed by means of the following amounts of lime :—
a. 56 g, *c.* 1 Kg, *e.* 523.36 g,
b. 7 lbs., *d.* 0.523 lbs., *f.* 57.57 g?
32. What amount of sal-ammoniac must be used to yield ammonia as follows :—
a. 34 lbs., *c.* 34.95 g, *e.* 1 lb.,
b. 17 g, *d.* 317.757 g, *f.* 1000 g?
- Solution: $2 \underbrace{(\text{NH}_4\text{Cl})}_{107} + \dots = 2 \underbrace{\text{NH}_3}_{34} + \dots$
- For 34 take 107, for one (1) also $\frac{107}{34}$ etc.
- Or: $\frac{?}{34} \mid \frac{34.95}{107}$ etc.
33. How much lime must be used to yield the following amounts of ammonia :—
a. 34 g, *c.* 8.5 g, *e.* 607.14 lbs.,
b. 17 lbs., *d.* 0.60714 g, *f.* 100 lbs.?
34. How much sal-ammoniac and lime are necessary to yield ammonia as follows :—
a. 1000 g, *b.* 10 lbs.?
35. It is required to make an ammonia solution, in which the water has absorbed 700 times its volume of ammonia gas. For this 10 liters of water are taken. What is the least quantity of sal-ammoniac and lime necessary? (Ans. in Kilos?)

V.—SULPHUR.

1. How much sulphur may be obtained from 840 lbs. of iron pyrites; how much burnt residue remains behind?
2. How much sulphur and residue may be obtained from the following quantities of pyrites:—
a. 1 Kg, *b.* 1000 lbs., *c.* 35 g, *d.* 1 lb.?
3. How much pyrites is necessary to obtain the following amounts of sulphur by distillation:—
a. 192 g, *c.* 1 lb., *e.* 25 $\frac{1}{7}$ lbs.?
b. 96 g, *d.* 8 Kg,
4. What amount of sulphurous acid (sulphur di-oxide) results from the decomposition of 32 g of sulphur?
5. How much sulphurous acid may be obtained by burning the following amounts of sulphur:—
a. 1 g, *b.* 20 lbs., *c.* 50 Kg, *d.* 1 Kg, *e.* 5 g?
6. What is the spec. grav. of sulphurous acid? (3 Vol. of the elements give 2 Vol. of the compound.). How does this proportion itself to the spec. grav. of sulphur gas and oxygen?
 What does 1 liter of sulphurous acid weigh? How much oxygen is contained in it?
7. How many liters of sulphurous acid are formed from the following amounts of sulphur:—
a. 1 g, *b.* 10 g?
8. How much sulphurous oxide may be obtained by the use of sulphuric acid and the following amounts of copper:—
a. 63.4 g, *b.* 6.34 lbs., *c.* 1 Kg 585 g, *d.* 1000 g?
9. What amount of copper sulphate will be formed in these cases?
10. How much sulphurous acid will result from the action of carbon on sulphuric acid as follows:—
a. 196 g, *b.* 98 lbs.?



From every 128 parts there will be formed 44, or from every 32 there will be 11 parts of carbon dioxide. From 1 part also $\frac{11}{32}$, etc.

Or: $\begin{array}{c|c} ? & 25 \\ 32 & 11 \end{array}$ etc.

19. How much (a) sulphuric acid, (b) sulphuric oxide must be reduced in order to obtain 64 parts by weight of sulphurous acid? How much oxygen must the sulphuric acid be deprived of?
20. How much sulphuric acid must be reduced in order to obtain the following amounts of sulphurous acid:—

a. 32 lbs.,	c. 5 Kg,
b. 5 lbs.,	d. 200 g?
21. What portion of the applied sulphuric acid will be reduced (a) by the use of copper, (b) charcoal?
22. How much sulphuric acid is needed to yield the following amounts of sulphurous acid (1) by means of copper, (2) by means of charcoal:—

a. 64 lbs.,	c. 10 lbs.,
b. 32 g,	d. 20 g?
23. How much sulphuric acid and copper are needed to yield sulphurous acid as follows:—

a. 1 Kg,	b. 100 lbs.?
----------	--------------
24. How much sulphuric acid and charcoal are necessary for the same quantities?
25. How much sulphuric acid and charcoal are necessary to yield 1 cu m sulphurous acid?
26. How much sulphuric acid and charcoal are needed for 100 liters of sulphurous acid?
27. How much sulphuric oxide is furnished by the oxidation of sulphurous acid as follows:—

a. 64 lbs.,	c. 1 lb.,
b. 32 g,	d. 1000 g?

28. What amount of oxygen will be consumed by the operation?
29. What amount of sulphuric acid corresponds to this? What is the amount of the combined water?

SULPHURIC ACID.

30. How much (1) sulphuric oxide, (2) sulphuric acid may be obtained from the sulphurous acid which comes from the following amounts of sulphur:—
- | | | |
|--------------------|----------------|---------------------|
| <i>a.</i> 32 lbs., | <i>c.</i> 8 g, | <i>e.</i> 100 lbs., |
| <i>b.</i> 1 lb., | <i>d.</i> 1 g, | <i>f.</i> 1 Kg? |
31. How obtain the quantity of sulphuric oxide which arises from a given quantity of, *a.* sulphur, *b.* sulphurous acid?
32. When 1 Kg of sulphur and the like amount of sulphurous acid are made into sulphuric acid, how much sulphuric oxide may this contain? How much water may it contain? How much of an acid containing 90 per cent. of a pure hydrated acid?
33. How much sulphurous acid is needed to form sulphurous oxide as follows:—
- | | | |
|--------------------|-------------------|---------------------|
| <i>a.</i> 80 g, | <i>c.</i> 1 Kg, | <i>e.</i> 11.335 g? |
| <i>b.</i> 20 lbs., | <i>d.</i> 5 lbs., | |
34. What quantities of sulphurous acid and water are necessary to form sulphuric acid as follows:—
- | | | |
|-------------------|-----------------------|----------------------|
| <i>a.</i> 98 g, | <i>c.</i> 6.125 lbs., | <i>e.</i> 14.700 Kg? |
| <i>b.</i> 7 lbs., | <i>d.</i> 1000 g, | |
35. How much oxygen is necessary for these?
36. How many cubic centimeters of oxygen are needed to convert 10 cu m of sulphurous acid into sulphuric acid? How much anhydride and hydrated acid may be obtained, and how many liters of water are necessary for the latter?
37. How much of an acid may be obtained, which, in addition to its water of composition, still may contain exactly $\frac{1}{2}$ its molecular weight of water?

38. What yield of sulphuric acid will these amounts of sulphur give, when no loss takes place *a.* 32 Kg, *b.* 16 cwt.? How much of an acid which has this composition: $\text{SO}_3, \text{H}_2\text{O} + \frac{1}{2}$ water? How much oxygen and air are necessary, and how much water remains in the acid obtained? (Oxygen 23 per cent. by weight of air.)
39. What is the quantity, by theory, of sulphuric acid resulting from—
a. 1 Kg, *b.* 100 lbs. of sulphur?
 How many cubic centimeters of oxygen and air (with 20.9 per cent. O) are consumed in the oxidation?
40. What amount of oxygen will be consumed to yield the English sulphuric acid from 50 Kg of sulphur; how much nitrogen will be eliminated; how much water absorbed; how much sulphuric acid, and acid of the composition designated in 38, generated? The quantity of oxygen is to be given which is consumed by the burning, and the amount which is necessary in the subsequent oxidation.
41. How much sulphur must be burnt; what is the least amount of *a.* oxygen, *b.* air to be introduced; how much water must be combined, to obtain 1091.8 Kg sulphuric acid of the composition given in 38 above; and how much nitrogen must be conducted off? Oxygen and air are to be given in Kg and cubic meters. (Composition of air as in IV. 5, 6.)

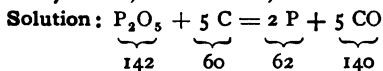
HYDROGEN SULPHIDE.

42. What is the percentage composition of hydrogen sulphide?
43. What is the spec. grav. of hydrogen sulphide, (hydrogen = 1), if by the union of the elements 3 volumes will be condensed to 2? What is the weight of 1 cu dm of hydrogen sulphide?

44. How much *a.* sulphurous acid, and *b.* water will furnish hydrogen sulphide as follows:—
a. 34 g, *b.* 17 g, *c.* 340 g, *d.* 2 lbs.?
45. How much *a.* sulphurous acid, *b.* water will furnish 1 cu m of hydrogen sulphide? (Ans. in grams and liters.)
46. How much oxygen will be consumed by this operation?
47. How much hydrogen sulphide may be obtained from ferrous sulphide as follows:—
a. 88 g, *c.* 22 g, *e.* 361.1 g,
b. 4 Kg 400 g, *d.* 1 lb., *f.* 1 Kg?
48. What amount of sulphuric acid is required for each of these decompositions?
49. How much ferrous sulphide and sulphuric acid are required to give hydrogen sulphide as follows;—
a. 34 lbs., *b.* 139.5 g, *c.* 3.24115 lbs., *d.* 1523.2 g?
50. What quantities of ferrous sulphide and sulphuric acid are needed to give *a.* 1 liter; *b.* 0.25 cu m of hydrogen sulphide?

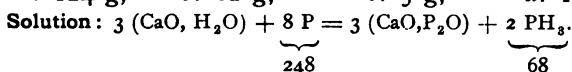
VI.—PHOSPHORUS.

1. How much phosphorus is contained in phosphoric acid (P_2O_5) as follows:—
a. 142 g, *b.* 35.5 lbs., *c.* 2 lbs., *d.* 5 g?
2. What is the least amount of pure carbon to be taken for a liquid containing free phosphoric oxide as follows, in order to obtain the phosphorus from it:—
a. 71 lbs., *b.* 1 lb., *c.* 10 g, *d.* 1 Kg?



For 142 parts by weight 60 parts by weight of carbon are needed; for 1 part by weight $\frac{60}{142}$, etc.

3. In these cases how much phosphorus and carbonic oxide will form?
4. When 677.48 g of phosphoric oxide are made by the burning of phosphorus, how much phosphorus is used; how much oxygen; how much air (according to volume) will be consumed?
5. How much phosphine gas may be obtained, according to theory, by means of phosphorus as follows:—
 - a.* 124 g, *b.* 62 g, *c.* 5 g, *d.* 10 g?



68 parts of phosphine may be obtained from 248 parts of phosphorus; $\frac{68}{248}$ from 1 part of phosphorus, etc.

6. What is the percentage composition of phosphine?
7. How many liters of phosphine, by theory, will the following amounts of phosphorus yield:—
 - a.* 100 g, *b.* 33.333 g?
8. In order to yield phosphine as follows, how much lime, water, and phosphorus are necessary by theory:—
 - a.* 34 g, *b.* 10 g, *c.* 1.5232 g?
9. How much of the same for—
 - a.* 1 liter, *b.* 0.25 cu m?

VII.—CARBON.

1. How much (1) carbon mon-oxide, (2) carbon di-oxide (carbonic acid) are furnished by burning 12 g of carbon?
2. How much of the same by burning carbon as follows:—
 - a.* 1 Kg, *c.* 1 cwt., *e.* 1500 g,
 - b.* 250 g, *d.* 0.12 g, *f.* 300 g?
3. What amount of oxygen will be consumed for this?

4. How would you find the quantity of *a.* carbon mon-oxide, *b.* carbonic acid which may arise from a given quantity of carbon? What is the quantity of oxygen necessary for both combustions?
5. What is the weight of 1 cu m *a.* carbon mon-oxide, *b.* carbonic acid?
6. How many cubic meters of oxygen are required for the complete combustion of 1000 Kg of carbon? How much air?
7. How many if only carbon mon-oxide is obtained?
8. How many cubic centimeters *a.* carbonic acid, *b.* carbon mon-oxide will be obtained in examples 6 and 7?
9. From the following quantities of carbonate of lime, how much carbonic acid may be obtained:—

<i>a.</i> 100 g,	<i>c.</i> 25 lbs.,	<i>e.</i> 1000 Kg,
<i>b.</i> 1 Kg,	<i>d.</i> 1 g,	<i>f.</i> 227.3 Kg?
10. How much carbonic acid may be obtained from a sufficient quantity of lime by means of—

<i>a.</i> 8.793 g of hydrochloric acid,	<i>b.</i> 11.805 g sul-phuric acid?
---	-------------------------------------
11. How much carbon mon-oxide may be obtained by conducting the generated gas over heated carbon?
12. A sufficient quantity of calcium carbonate will yield how much carbonic acid by means of—

<i>a.</i> 233 $\frac{1}{3}$ lbs.,	<i>b.</i> 4666.667 g,
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 of a muriatic acid containing 30 per cent. of pure hydrochloric acid?
13. What amount of carbon mon-oxide will be obtained by passing 30 lbs. of carbonic acid over heated charcoal, and how much will the weight of the tube be diminished or increased?
14. What amount of carbonic acid must be passed through a vessel which contains 5.625 g of heated charcoal until this entirely disappears, if it be granted that the whole amount of carbonic acid should be-

23. How much carbon must be burnt to produce carbonic acid as follows :—
a. 44 lbs., *c.* 352 g, *e.* 4 Kg 400 g,
b. 22 g, *d.* 1971.2 g, *f.* 122.1 g?
24. How much to produce, *a.* 1860.1 cu m, *b.* 1000 cu m?
25. What quantities of acid potassium oxalate and sulphuric acid are needed to yield, *a.* 55.8 cu dm, *b.* 74.4 cu m of carbon mon-oxide?

Solution: First it is necessary to find the weights of the required gases, then, according to the formula in example 17, that of acid potassium oxalate, and afterwards that of the sulphuric acid, of which two molecules by weight were necessary.

26. How much calcium carbonate, muriatic acid containing 30 per cent. of hydrochloric acid gas, and carbon are needed to yield 30 g of carbon mon-oxide?
27. How much calcium carbonate and sulphuric acid with $\frac{1}{2}$ the molecular weight of water, besides the hydrate, are needed for 1 cu m of carbonic acid?
28. What amount of calcium carbonate would be required for the evolution of carbonic acid, when 1000 liters of water under a pressure of 4 atmospheres shall have been saturated by the evolved gases? How much sulphuric acid is necessary for this?

CARBON DISULPHIDE.

29. How much sulphur must be transformed into vapor to yield carbon di-sulphide as follows :—
a. 76 g, *b.* 38 lbs., *c.* 5 lbs., *d.* 20 g?
 How much lighter will the tube containing the carbon become?

HYDRO CARBONS.

30. What is the percentage composition of ethylene gas?
31. What is the percentage composition of mine gas?

32. How much oxygen is needed to burn 1 cu m of ethylene and what results?
 33. How much oxygen is required to burn 1 cu dm of mine gas; and how much of both of the burnt products will be obtained?
-

VIII.—FLUORINE.

1. What is the percentage composition of hydrofluoric acid?
2. How much hydrofluoric acid may be obtained from fluorspar as follows :—

a. 78 g,	b. 39 lbs.,	c. 25 g,	d. 1 Kg?
----------	-------------	----------	----------
3. What amount of hydrofluoric acid, containing 36 per cent. of the acid contents, may be obtained from a sufficient quantity of fluorspar by means of sulphuric acid as follows :—

a. 98 lbs.,	d. 49 g,
c. 12.25 g,	e. 12 g?
4. How much fluorspar and sulphuric acid are required to yield hydrogen fluoride as follows :—

a. 20 lbs.,	d. 30 g,
b. 10 g,	e. 1 Kg,
c. 1 g,	f. 1 lb.?
5. What amount of fluorspar and sulphuric acid are necessary to yield the following quantities of hydrogen fluoride containing 20 per cent. of water, and how much water will be consumed :—

a. 25 g,	d. 1 g,
b. 35 lbs.,	e. 1 lb.?
c. 5 g,	
6. What amount of calcium sulphate will be obtained by the preparation of hydrogen fluoride as follows :—

a. 40 g,	c. 1 g,
b. 20 lbs.,	d. 30 g?

IX.—POTASSIUM.**POTASSIUM HYDRATE.**

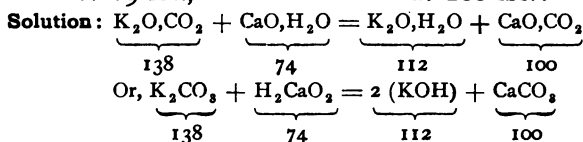
1. What amount of potassium hydrate will the following quantities of potassium carbonate yield :—

a. 138 lbs.,

c. 1 Kg,

b. 69 lbs.,

d. 200 lbs. ?



2. How much (1) calcium oxide, (2) calcium hydrate are necessary for this; and how much potassium carbonate remains behind ?
3. What amount of burnt lime and potassium carbonate are required to yield caustic potash as follows :—

a. 112 lbs.,

c. 25 g,

b. 1 lb.,

d. 811.6 g ?

POTASSIUM CARBONATE.

4. How much tartar must be heated to furnish pure potassium carbonate as follows :—

a. 69 g,

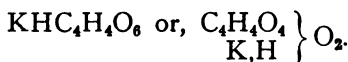
d. 1 Kg,

b. 138 lbs.,

e. 25 g ?

c. 1 lb.,

Formula of cream of tartar :—



5. How much potassium chloride must be precipitated with tartaric acid, to obtain the necessary quantities of tartar for yielding pure potassium carbonate as follows :—

a. 6 g,

d. 1 Kg,

b. 100 g,

e. 25 g ?

c. 10 lbs.,

Solution: It is easy to reckon the last quantity and from this the quantity of potassium chlorate, yet this is not necessary, since the quantity of potassium remains unchanged in all compounds. We can determine directly the chloride of potassium from the carbonate, in doing which we must bear in mind the unlike number of atoms.

POTASSIUM NITRATE.

6. What is the percentage composition of saltpeter?
7. How much potassium nitrate can be obtained from calcium nitrate as follows:—
 - a.* 1000 g,
 - b.* 12 cwt.,
 - c.* 1000 lbs.?
8. How much potassium carbonate is necessary for this?
9. What quantities of calcium nitrate and potassium carbonate are needed to yield saltpeter as follows:—
 - a.* 202 lbs.,
 - b.* 100 lbs.,
 - c.* 1231.7 g,
 - d.* 14 cwt., 78 lbs.,
 - e.* 1000 cwt.?
10. What is the least quantity of calcium carbonate that must be mixed with 1000 hundred-weight of a substance containing 12 per cent. nitrogen, for the formation of saltpeter, and how much saltpeter may be obtained according to theory?
11. How much potassium nitrate and sulphuric acid are needed, and how much water must be consumed to yield nitric acid as follows containing $80\frac{5}{7}$ per cent. of anhydride:—
 - a.* 72.71 lbs.,
 - b.* 22.3 g?
12. What amount of potassium nitrate, sulphuric acid, and water are necessary to furnish 1 Kg of aquafortis containing 28.5 per cent. of nitric anhydride?
13. How much sulphur and carbon, supposed to be pure, must be mixed, by theory, with 100 parts of saltpeter in order to yield gunpowder?
14. What is the percentage composition of gunpowder, according to theory, when mixed with pure materials?

25. How much liver of sulphur may be obtained, and carbonate liberated?
 26. What amount of pentasulphide of potassium is contained in the obtained amounts of liver of sulphur?
 27. What per cent.?
 28. *a.* How is the quantity of sulphur contained in the sulphide of potassium related to that contained in the potassium sulphate?
b. What amount of the sulphur taken may be obtained as milk of sulphur, by the use of liver of sulphur with hydrogen chloride?
 29. The sulphur and potassium carbonate, that are heated together, bear what relation to each other?
-

X.—SODIUM.

(The examples which are related to the preceding, and are similar to those of potassium, are omitted in this place.)

1. When you are dealing with a chemical reaction, in which caustic soda or caustic potash shows the same phenomena, which of the substances is it advisable to employ, if the price is the same?
2. If the price of potassium carbonate and
 - a.* Carbonate of soda free from water,
 - b.* " " containing wateris the same, which of the two substances is it better to use, other things being equal?
3. *a.* How must the prices of the substances stand, if in this respect it is immaterial which of the two is used?
b. How must the price of the anhydrous sodium carbonate, regardless of other circumstances, proportion itself to that of the hydrous, if only the real value be considered?

4. What is the percentage composition of sodium carbonate—
a. effloresced,
b. crystallized?
5. How much soda will the following quantities of sodium sulphate yield:—
a. 426 lbs., *c.* 71 Kg, *e.* 1000 Kg,
b. 213 lbs., *d.* 1000 lbs., *f.* 70 cwt.,
 if the following formulæ be made the basis of the soda process:—

$$3 (\text{Na}_2\text{O}, \text{SO}_3) + 4 (\text{CaO}, \text{CO}_2) + 13 \text{ C} =$$

$$3 (\text{Na}_2\text{O}, \text{CO}_2) + 3 (\text{CaS}) + \text{CaO} + 14 \text{ CO?}$$
 Or,
$$3 \text{ Na}_2\text{SO}_4 + \text{CaCO}_3 + 13 \text{ C} =$$

$$3 \text{ Na}_2\text{CO}_3 + 3 \text{ CaS} + \text{CaO} + 14 \text{ CO?}$$
6. How much calcium carbonate and carbon are required by this acceptance, according to theory, for the decomposition of the above quantities, pure material supposed?
7. How much anhydrous sodium sulphate, calcium carbonate, and carbon, under like conditions are needed to yield anhydrous carbonate of soda as follows:—
a. 318 lbs., *c.* 1000 lbs.,
b. 746.48 Kg, *d.* 500 Kg?
8. What amounts of crystallized sodium sulphate, carbonate of lime, and carbon, under the same conditions, are necessary according to theory to yield crystallized sodium carbonate as follows:—
a. 858 lbs., *c.* 1000 cwt.,
b. 143 cwt., *d.* 100 Kg?
9. How much sodium chloride must be employed in the operation to yield the desired quantities in 7, and how much muriatic acid gas will be set free?
10. What are the quantities of the different materials that, under the same suppositions, are necessary for

the production of 100 Kg of anhydrous carbonate of soda, and what are the resulting products by this operation?

BI-CARBONATE OF SODA.

11. What is the percentage composition of bi-carbonate of soda?
12. How many cu cm of carbonic acid, at 0° , does 1 g bicarbonate of soda yield, when it is decomposed by the excess of acid?
13. How many cu dm carbonic acid can be obtained from a solution which contains 53 g of anhydrous carbonate of soda, if this be converted into acid salts?
14. In what proportion must crystallized and anhydrous carbonate of soda be mixed, that the mixture may receive the required quantity for the production of the acid salts?
15. How many cubic decimeters of carbonic acid are evolved by heating 1 Kg bi-carbonate of soda?
16. In what proportion should bi-carbonate of soda and tartaric acid ($C_4H_6O_6$) be mixed, if after the dissolution, neither of them shall remain in excess?

BORAX.

17. What is the percentage composition of borax?
18. What is the percentage composition of the octahedral borax?
19. How much borax can be obtained from *a.* 1500 cwt.,
b. 1000 Kg of a liquid containing 3 per cent. boracic acid, and how much anhydrous carbonate of soda is necessary for this?
20. What amount of octahedral borax is needed to obtain borax glass as follows:—
a. 100 g, *b.* 20 lbs.?

21. What is the percentage composition of common salt—
- a.* in 100 parts?
 - b.* for 100 parts of sodium?
 - c.* “ “ chlorine?
-

XI.—AMMONIUM.

1. In what relation do the gases stand by volume of the decomposed products of mercuric di-ammonide ($\text{Hg}[\text{NH}_4]_2$)? In what relation do the same stand by weight?
2. What quantities of ammonium sulphate and common salt are required to yield ammonium chloride as follows:—
 - a.* 100 cwt.,
 - b.* 80 g,
 - d.* 10 lbs.,
 - c.* 4 g?
3. How much neutral ammonium carbonate (di-ammonium carbonate) will be necessary, how much gypsum decomposed, and how much sulphate of soda formed, to yield 100 lbs. of ammonium chloride?
4. How much sesqui-carbonate of ammonia is necessary to form 90.678 g ammonium chloride, and how much hydrochloric acid will be neutralized by these means from these quantities?
5. How much of a liquid, containing 15 per cent. sesqui-carbonate of ammonium, is required to yield 100 lbs. of sal-ammoniac, and how much muriatic acid, of 20 per cent. acid content of hydrochloric acid, is necessary for this?
6. What is the percentage composition of a liquid in sesqui-carbonate of ammonium, of which 581.915 g are necessary, in order to neutralize 40 g of a muriatic acid containing 18 per cent. of hydrochloric acid?
7. What is the percentage amount of ammonia in a liquid, if 2.5 g yield 0.27537 g of sal-ammoniac, with an indefinite amount of muriatic acid?

XII.—BARIUM.

1. How much barium sulphide, barium hydrate, barium nitrate, and barium chloride must be obtained, according to theory, from barium sulphate as follows:—
 - a.* 233 lbs.,
 - b.* 116.5 g,
 - c.* 100 g,
 - d.* 1 Kg?
2. How much charcoal is necessary for the reduction of these quantities, and how much carbonic oxide will be formed?
3. What amount of heavy spar is needed, and what is the least amount of charcoal that must be added, to yield barium chloride as follows:—
 - a.* 104 g,
 - b.* 47.318 g,
 - c.* 250 g,
 - d.* 100 lbs.?
4. What quantity of barium sulphate and potassium carbonate must be heated together to yield barium carbonate as follows:—
 - a.* 197 g,
 - b.* 98.5 lbs.,
 - c.* 100 lbs.,
 - d.* 1 Kg?
5. How much barium chloride is in a liquid, which will be precipitated immediately by 4.71154 g of sulphuric acid?
6. What per cent. of anhydrous sulphuric acid is contained in a liquid, of which 21.5 g are required for the precipitation of 5.6 g of barium chloride?
7. Will still another compound be set free by this precipitation? What and how much?
8. What per cent. of barium nitrate may a substance contain, of which 19.98 g yield a precipitate with a sulphuric acid compound which weighs 0.89183 g?
9. If it is required to precipitate 4.5 g of barium chloride by means of carbonic acid, how much ammonium oxide, in the form of ammonium and H_2O , must be added to the solution? How much secondary ammonium carbonate is required for the preparation?

10. How much crystallized sodium carbonate and barium chloride are needed to yield barium carbonate as follows:—
a. 20 g, *b.* 1 lb., *c.* 1 Kg?
11. Will a bye-product be obtained, and how much?
-

XIII.—CALCIUM.

1. How much burnt lime may be obtained from calcium carbonate as follows:—
a. 100 lbs., *c.* 1 lb.,
b. 1000 Kg, *d.* 25 g?
2. How much calcium hydrate may be obtained from the same quantities?
3. What quantities of calcium carbonate must be burnt to yield burnt lime as follows:—
a. 56 lbs., *c.* 140 Kg, *e.* 1000 Kg,
b. 14 cwt., *d.* 100 lbs., *f.* 5 cwt.?
4. How many cu m of carbonic acid will be liberated in each case?
5. How much H_2O is necessary to slake these quantities of lime?
6. How many cu m of carbonic acid can a milk of lime absorb which contains lime as follows:—
a. 56 lbs., *c.* 100 Kg,
b. 100 lbs., *d.* 14 Kg?
7. When a pure calcium carbonate is formed, calcium chloride may be precipitated with sodium carbonate. How much of both are required to yield calcium carbonate as follows:—
a. 40 g, *c.* 100 g,
b. 1 Kg, *d.* 5 lbs.?
8. What is the percentage composition of *a.* unburnt, *b.* burnt gypsum?
-

9. How much water is necessary to harden completely the following amounts of burnt gypsum, if it be granted that no loss is sustained :—

a. 68 lbs.,	c. 1 Kg,
b. 17 g,	d. 50 g ?
10. What amount of acid calcium phosphate is necessary to yield, by precipitation, anhydrous phosphoric acid as follows :—

a. 142 g,	b. 50 lbs.,	c. 1 Kg ?
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11. What is the percentage composition, according to theory, of anhydrous calcium chloride, corresponding to the formula ?
12. What amount of chlorine and lime is necessary to yield anhydrous chloride of lime as follows, according to theory, if it be granted that no loss is sustained :—

a. 254 lbs.,	c. 25 g,
b. 127 g,	d. 100 Kg ?
13. How many liters or cu m of chlorine are necessary, by the same suppositions, for—

a. 254 g,	b. 100 lbs.,	c. 100 Kg,
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calcium chloride ?
14. What quantity of hydrochloric acid and black oxide of manganese are required to evolve the necessary chlorine in example 12 ?
15. How much calcium hydrate and black oxide of manganese, and how much muriatic acid of 30 per cent. acid content, are necessary to yield 1000 lbs. of calcium chloride; if this be taken anhydrous and contain only 35 per cent. of the whole amount of chlorine ?
16. What quantity of black oxide of manganese, 25 per cent. muriatic acid, and calcium hydrate are required, under the known conditions, to yield 100 Kg of a chloride of lime which contains 64 per cent. of calcium hydrate ?

17. If, by a calcium determination, 2.5 g of calcium carbonate are obtained by heating the precipitated calcium oxalate, what amounts of—
a. lime,
b. calcium chloride,
c. " sulphate,
 may be calculated out of this?
 18. What per cent. if 7.5 g be taken for the analysis?
-

XIV.—MAGNESIUM.

1. What quantity of magnesite is required to yield 1000 Kg of crystallized magnesium sulphate?
2. What is the percentage composition of magnesia alba, the formulæ producing it corresponding to—

$$\text{MgO}, \text{H}_2\text{O} + 3 (\text{MgO}, \text{CO}_2) + \text{H}_2\text{O}?$$
 Or, $\text{MgO}_2\text{H}_2 + 3 \text{CO}_2\text{Mg} + \text{H}_2\text{O}?$
 Or, $\text{C}_3\text{O}_{12}\text{Mg}_4\text{H}_4?$
3. How much crystallized magnesium sulphate and potassium carbonate are needed to yield magnesia alba as follows :—

<i>a.</i> 164 g,	<i>c.</i> 100 lbs.,
<i>b.</i> 41 lbs.,	<i>d.</i> 1000 Kg?
4. Is the quantity of obtained magnesia and potassium sulphate, bearing in mind the elimination of the water of crystallization, equal to the sum of the employed substances? In what does the difference lie? Loss or gain? Which material is the cause?
5. How much magnesia alba (of the composition as above) must be heated to yield pure magnesia as follows :—

<i>a.</i> 20 lbs.,	<i>c.</i> 100 lbs.,
<i>b.</i> 4 g,	<i>d.</i> 1000 g?

6. What is the percentage composition of ammonia magnesium phosphate? What per cent. of this precipitate remains behind by heating?
7. How much magnesia was contained in a liquid, which, by the precipitation with sodium phosphate and ammonia, gave precipitates as follows :—
- a.* 1.11 g, *b.* 3.7 g, *d.* 2.5 g?
8. What per cent. (1) phosphoric acid, (2) anhydrous sodium phosphate do the substances contain, of which 2.25 g gave a precipitate with Epsom salts and ammonia, which after heating left residues as follows :—
- a.* 1.11 g, *c.* 0.37 g,
b. 1.85 g, *d.* 0.074 g?
-

XV.—ALUMINIUM.

1. What per cent. of *a.* alumina, *b.* alumina sulphate do (1) potash alum, (2) soda alum, (3) ammonia alum contain?
2. *a.* What per cent. of water do these alums contain?
b. What per cent. of their weight will be left by heating?
3. What is the percentage composition of feldspar?
4. What amount of potash alum and potassium carbonate are needed to yield alumina as follows, and how much carbonic acid will be set free :—
- a.* 102.8 g, *c.* 10 lbs.,
b. 25.7 lbs., *d.* 1 Kg?
-

XVI.—IRON.

1. What per cent. of iron must be left from the following earths taken pure, if there is no loss :—
- a.* magnetic iron ore, *c.* brown iron ore,
b. hematite, *d.* spathose iron ore?

11. What amount of crystallized green vitriol, is to be ignited, after its dehydration, in order, without previous roasting, to yield anhydrous sulphuric acid as follows :—

<i>a.</i> 40 lbs.,	<i>c.</i> 200 g,
<i>b.</i> 20 g,	<i>d.</i> 100 lbs.?
12. How much is necessary if it has been previously roasted?
13. What quantity of water must be expelled from every 100 parts for the obtained anhydrous acid *a.* when it has not been roasted, *b.* when it has been roasted?
14. How much potassium sulphate and neutral ferric sulphate are necessary to yield—

<i>a.</i> 503 g,	<i>b.</i> 20 g,	<i>c.</i> 1 lb.,
------------------	-----------------	------------------

potash iron alum?
15. What is the percentage composition of crystallized ferro-cyanide of potassium?
16. What of ferri-cyanide of potassium?
17. How much iron and potassium carbonate will be required to yield—

<i>a.</i> 211 g,	<i>b.</i> 100 lbs.,	<i>c.</i> 1000 Kg,
------------------	---------------------	--------------------

of ferro-cyanide of potassium, if there is no loss?
18. What amount of ferro-cyanide and ferric chloride, both anhydrous, are necessary to yield—

<i>a.</i> 860 g,	<i>c.</i> 100 lbs.,
<i>b.</i> 43 lbs.,	<i>d.</i> 1000 Kg,

of Prussian blue?
19. How much pure ferrous-cyanide will be obtained from—

<i>a.</i> 184 g,	<i>c.</i> 100 g,
<i>b.</i> 46 lbs.,	<i>d.</i> 552 lbs.,

of ferro-cyanide (anhydrous), when ferrous sulphate is employed and a pure compound is precipitated? How much of the iron salt is necessary for this operation?

20. What amount of ferrous-cyanide is necessary to make Prussian-blue as follows, by the oxydation of the cyanide, when this is freed from the mixed oxide by nitric acid :—
- | | |
|------------------|-----------------------|
| <i>a.</i> 860 g, | <i>c.</i> 100 g, |
| <i>b.</i> 215 g, | <i>d.</i> 1000 lbs. ? |
- What is the weight of the oxide to be removed ?
21. What quantity of ferro-cyanide and ferrous sulphate, both anhydrous, are required to yield—
- | | |
|---------------------|----------------------|
| <i>a.</i> 430 lbs., | <i>c.</i> 1000 cwt., |
| <i>b.</i> 100 lbs., | <i>d.</i> 500 Kg, |
- of Prussian-blue, if the precipitate thrown down by the mixing of both compounds be entirely freed from the oxide, and ferrous-ferric cyanide be accepted as pure ?
22. How many cu dm of chlorine must act upon the solution of—
- | | | |
|------------------|-----------------|-------------------|
| <i>a.</i> 422 g, | <i>b.</i> 20 g, | <i>c.</i> 2.5 Kg, |
|------------------|-----------------|-------------------|
- of crystallized ferro-cyanide to convert this into ferri-cyanide of potassium ?
23. What amount of ferri-cyanide of potassium may be obtained in these cases ?
24. How much crystallized ferro-cyanide must be taken to yield ferri-cyanide as follows :—
- | | |
|----------------------|------------------|
| <i>a.</i> 329 g, | <i>c.</i> 25 g, |
| <i>b.</i> 10.3 lbs., | <i>d.</i> 1 Kg ? |
-

XVII.—MANGANESE.

1. What quantity of carbonic oxide will be liberated when—
- | | |
|-------------------|----------------------|
| <i>a.</i> 87 g, | <i>c.</i> 2.18 lbs., |
| <i>b.</i> 4.36 g, | <i>d.</i> 10 g, |
- of manganese di-oxide are mixed with neutral potassium oxalate and covered with sulphuric acid ?

2. How much manganese di-oxide do four manganese tests contain, of which every 3.27 g by these tests yield carbonic acid as follows:—
- | | |
|-------------------|-------------------|
| <i>a.</i> 2.24 g, | <i>c.</i> 3 g, |
| <i>b.</i> 2.50 g, | <i>d.</i> 1.25 g? |
3. About how much lighter will a strip of copper become if it be laid in a mixture of muriatic acid and the following quantities of manganese di-oxide:—
- | | | |
|-------------------|-------------------|----------------|
| <i>a.</i> 43.5 g, | <i>b.</i> 1.45 g, | <i>c.</i> 1 g? |
|-------------------|-------------------|----------------|
4. What per cent. of manganese di-oxide do the four manganese tests contain, by which a strip of copper of these weights, with muriatic acid, has lost each time 4 g of manganese:—
- | | |
|----------------|-------------------|
| <i>a.</i> 4 g, | <i>c.</i> 5.25 g, |
| <i>b.</i> 2 g, | <i>d.</i> 3.15 g, |
-

XVIII.—CHROMIUM.

1. What is the percentage composition of chromic iron?
2. How much chromic acid (anhydric) may be obtained from chromic oxide as follows:—
- | | |
|------------------|------------------|
| <i>a.</i> 152 g, | <i>c.</i> 1 lb., |
| <i>b.</i> 100 g, | <i>d.</i> 1 Kg? |
3. What quantity of di-chromate of potassium may be obtained from the same quantities of chromic oxide by melting with potassium carbonate and saltpeter?
4. How much pure chromic iron and potassium carbonate must be taken to yield potassium di-chromate as follows:—
- | | |
|------------------------|---------------------|
| <i>a.</i> 294 g, | <i>c.</i> 100 lbs., |
| <i>b.</i> 131.25 lbs., | <i>d.</i> 1 Kg? |
5. What amount of di-chromate of potassium and sulphuric acid are necessary to yield chrome alum as follows:—
- | | | |
|------------------|---------------------|-----------------|
| <i>a.</i> 998 g, | <i>b.</i> 100 lbs., | <i>c.</i> 25 g? |
|------------------|---------------------|-----------------|
- What amount of water will be taken up with it?

6. What is the amount of potassium chromate, that must be reduced and precipitated, to yield, after heating—
a. 152 g, *c.* 100 g,
b. 30 g, *d.* 1 lb.,
of chromic oxide?
7. How much di-chromate of potassium, sal-ammoniac, and potassium carbonate must be heated to yield—
a. 152 g, *b.* 50 g, *c.* 1 lb.,
chromic oxide?
8. How much neutral potassium chromate and lead acetate ($\text{Pb}_2\text{C}_4\text{H}_6\text{O}_4 + 3 \text{H}_2\text{O}$) are necessary to obtain lead chromate as follows:—
a. 323 g, *c.* 50 g,
b. 10 lbs., *d.* 1 Kg?
9. What per cent. chromic acid does a liquid contain, 20.11 g of which give a precipitate of barium chromate weighing—
a. 4.500 g, *b.* 10.438 g?
10. What quantity of sulphuric acid is necessary to convert—
a. 194 g, *c.* 10 g,
b. 97 lbs., *d.* 25 g,
of the potassium chromate into the acid salt?
-

XIX.—ZINC.

1. What per cent. should *a.* zinc-blende, *b.* calamine yield, according to theory, if these be pure, and there is no loss?
2. How many cu cm of zinc (spec. grav. 7.2) must be burned to obtain—
a. 40.5 g, *b.* 5.0625 g, *c.* 10 g,
of zinc oxide?

- ## XX.—COPPER.

- How much anhydrous copper nitrate must be heated, to obtain cupric oxide as follows :—
 - 79.4 g,
 - 39.7 lbs.,
 - 100 g,
 - 10 lbs. ?
- How much of the copper nitrate containing 3 H₂O is required for this purpose ?

3. What quantity of the last mentioned salt must be dissolved, precipitated with alkali, and heated to obtain the same quantity of copper oxide?
4. What amounts of white vitriol and carbonate of soda are necessary to yield cupric oxide as follows:—
- | | |
|----------------------|--------------------|
| <i>a.</i> 79.4 g, | <i>c.</i> 100 g, |
| <i>b.</i> 39.7 lbs., | <i>d.</i> 10 lbs.? |
5. How much copper must be dissolved by nitric acid to obtain cupric oxide as follows, after the precipitation of the salt obtained, and heating of the precipitate:—
- | | |
|--------------------------|-------------------------|
| <i>a.</i> 79.4 g, | <i>d.</i> 62.6183 g, |
| <i>b.</i> 39.7 g, | <i>e.</i> 12.5237 lbs.? |
| <i>c.</i> 125.2366 lbs., | |
6. How much lighter will a given quantity of copper filings become, if copper oxide be formed from it in weight as follows:—
- | | |
|----------------------|-------------------|
| <i>a.</i> 39.7 lbs., | <i>c.</i> 100 g, |
| <i>b.</i> 125.237 g, | <i>d.</i> 5.01 g? |
7. What quantity of cupric oxide must be heated with—
- | | |
|-------------------|-------------------|
| <i>a.</i> 63.4 g, | <i>c.</i> 5 lbs., |
| <i>b.</i> 10 g, | <i>d.</i> 50 g, |
- of copper to obtain cuprous oxide, and how much of the last will be formed?
8. How many cu dm of oxygen will be taken up by a liquid which contains—
- | | | |
|-------------------|------------------|----------------------|
| <i>a.</i> 71.4 g, | <i>b.</i> 100 g, | <i>c.</i> 63.9744 g, |
|-------------------|------------------|----------------------|
- of cuprous oxide in solution?
9. How much oxygen can be absorbed by a liquid which contains in solution the cuprous oxide, originating from the reduction of—
- | | |
|--------------------|---------------------|
| <i>a.</i> 159.4 g, | <i>b.</i> 223.25 g, |
|--------------------|---------------------|
- of copper sulphate?

10. How many cu dm of oxygen will be absorbed by copper which is moistened with—
a. 196 g, *b.* 274.5 g,
of sulphuric acid, containing 25 per cent. of hydrate? How much copper will be dissolved by this operation?
11. How much copper sulphate will be obtained from—
a. 158.8 lbs., *c.* 1000 Kg,
b. 100 lbs., *d.* 500 lbs.,
cuprous sulphide, if this be pure, only roasted and lixiviated with water?
12. What amount may be obtained if the roasted mass be lixiviated with water containing sulphuric acid?
13. What per cent. of crystallized blue vitriol may be obtained from an ore containing 7.5 per cent. cuprous sulphide, with no losses sustained?
14. How much copper is obtained from—
a. 1000 lbs., *c.* 1 lb.,
b. 100 Kg, *d.* 1 g,
water-cement which contains 10.5 per cent. copper, copper vitriol?
15. How much green vitriol will crystallize out of the liquid obtained by the precipitation with iron?
16. What quantity of crystallized blue vitriol may be obtained from a copper ore which contains 7.5 per cent. cuprous sulphide, if—
a. 1000 lbs., *c.* 5000 Kg,
b. 50 Kg, *d.* 1000 cwt.,
be employed in the operation?
17. If no loss is sustained, what per cent. should the following pure copper ores yield:—
a. red copper ore, *d.* variegated,
b. black copper, *e.* malachite,
c. chalcopryite, *f.* azurite?

- ## XXI.—MERCURY.

- I. How much mercuric chloride must be mixed with mercury to yield calomel as follows:—
- | | |
|------------|--------------|
| a. 471 g, | c. 3 Kg, |
| b. 94.2 g, | d. 56 lbs. ? |

2. What quantity of mercuric sulphate, quicksilver, and common salt must be sublimed to yield—

<i>a.</i> 471 g,	<i>c.</i> 5 lbs.,
<i>b.</i> 15.7 lbs.,	<i>d.</i> 10 g,

 of calomel?
3. How much mercuric sulphate and salt must be subjected to sublimation in order to obtain—

<i>a.</i> 135.5 g,	<i>b.</i> 54.2 g,	<i>c.</i> 100 g,
--------------------	-------------------	------------------

 of corrosive sublimate?
4. How much quicksilver must be dissolved, when precipitated as oxide and dissolved in muriatic acid, to furnish corrosive sublimate as follows:—

<i>a.</i> 135.5 g,	<i>c.</i> 10 Kg,
<i>b.</i> 4 lbs.,	<i>d.</i> 100 g?
5. How much quicksilver ore, containing 24 per cent. of cinnabar, must be consumed to get—

<i>a.</i> 110 lbs.,	<i>c.</i> 1000 Kg,
<i>b.</i> 500 lbs.,	<i>d.</i> 100 cwt.,

 of quicksilver?
6. By the analysis of three liquids, which contain different quantities of mercuric chloride, there will be obtained from every 10 g of the same, precipitated with stannous chloride—

<i>a.</i> 0.5 g,	<i>b.</i> 1.1235 g,	<i>c.</i> 1.4500 g,
------------------	---------------------	---------------------

 of quicksilver. What amount of sublimate does each of the three liquids contain?
7. How much quicksilver must be taken with an excess of nitric acid to obtain—

<i>a.</i> 17.28 g,	<i>b.</i> 100 g,
--------------------	------------------

 crystallized basic mercuric nitrate?

Formulae of salt:—

$$2 \text{ HgO}, \text{N}_2\text{O}_5 + 2 \text{ H}_2\text{O}.$$

Or, $2 (\text{NO}_3) \text{ Hg}, \text{HgO} + 2 \text{ H}_2\text{O}.$
8. In what proportion must mercury be mixed with iodine to obtain mercuric iodide?

XXII.—LEAD.

1. How much lead nitrate must be heated to give—
a. 223 g, *b.* 100 g, *c.* 5 lbs.,
of litharge?
2. What amount of lead must be oxydized to obtain the same quantities?
3. How many cu dm (1) oxygen, (2) air are required for this oxydation? (Vid. IV, 5.)
4. What amount of red oxide of lead is necessary to yield plumbic peroxide as follows, if this be taken as the formula for red lead Pb_4O_6 :—
a. 239 g, *c.* 13.3 g,
b. 39.9 lbs., *d.* 1 lb.?
5. How much oxygen is absorbed by lead oxide, if red lead, corresponding to the formula Pb_3O_4 , be formed as follows :—
a. 685 g, *c.* 100 g,
b. 137 lbs., *d.* 1 lb.?
6. What amount of lead must be worked in order to produce white lead as follows :—
a. 775 lbs., *c.* 1000 cwt.,
b. 100 lbs., *d.* 10 Kg?
7. How many cu m of carbonic acid are needed for it?
8. How much plumbic oxide must be dissolved in the following quantities of crystallized neutral acetate of lead to obtain basic salts :—
a. 379 lbs., *c.* 25 g,
b. 1 lb., *d.* 189.5 g?
9. What amount of lead oxide will be precipitated, by means of carbonic acid, from the basic salts obtained in (8)?
10. When white lead is to be obtained from a given quantity of plumbic oxide, and acetic acid only applied once, then precipitated with carbonic acid; how much acetic acid is necessary?

11. How much of the plumbic oxide is obtained in the white lead?
12. What quantity of white lead may be obtained by once dissolving and precipitating from—
 - a.* 1000 Kg,
 - b.* 100 lbs.,
 of plumbic oxide?
13. How much plumbic oxide must be taken under the same suppositions to yield white lead as follows:—
 - a.* 1550 lbs.,
 - c.* 77.23 Kg,
 - b.* 772.3 lbs.,
 - d.* 1000 Kg?
14. When there is no loss, what per cent. of lead must the following ores yield:—
 - a.* galena,
 - b.* cerusite,
 - c.* anglesite?
15. How much lead ore, containing 45 per cent. galena, is necessary to produce lead as follows:—
 - a.* 1 lb.,
 - c.* 100 Kg,
 - b.* 1000 lbs.,
 - d.* 4000 Kg?
16. What per cent. of lead do three alloys contain, of which every—

1.5231 g,	2.0026 g,	4.1170 g,
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 after being dissolved in nitric acid, give precipitates with sulphuric acid weighing—
 - a.* 1.4854 g,
 - b.* 1.4658 g,
 - c.* 4.2184 g?

XXIII.—SILVER.

1. What per cent. of silver does silver nitrate contain?
2. How much pure silver must be dissolved to give silver nitrate as follows:—
 - a.* 340 g,
 - c.* 5 g,
 - b.* 1 g,
 - d.* 100 g?
3. How much silver nitrate may be obtained from three mark pieces when the same together weigh 16.7 g and contain 90 per cent. of silver?

4. 100 marks may be coined from a pound of silver, and as much copper added as to make the compound 0.900. How much cupric nitrate (with three molecules of H_2O) may be obtained from the solution of 100 marks? How much lunar caustic?
5. How many marks are dissolved to yield caustic as follows, if a mark weighs 5.556 g and has fine quality of 0.900:—
 - a.* 100 g, *b.* 1 lb., *c.* 78.71 g?
6. What amount of *a.* HCl, *b.* barium chloride, *c.* sodium chloride is contained in a liquid from which silver solutions give a precipitate weighing 3.59 g?
7. What per cent. of chlorine do two substances contain of which—
 - a.* 2.1340 g, *b.* 3.4203 g,
 give a precipitate of silver chloride weighing 1.19667 g?
8. How much must the precipitates weigh which give pure sodium chloride as follows, with a silver solution:—
 - a.* 5.2401 g, *b.* 2.0301 g?
9. What per cent. of pure silver is contained in an alloy, of which 2.505 g, with a solution of common salt, give a precipitate amounting to 2.66272 g?
10. How much plumbic oxide can be obtained from 1000 lbs. of lead which contains 0.5 g of silver to the pound?
11. How much gold, silver, and crystallized blue vitriol may be obtained by the refining of 1500 g of silver which contains $\frac{1}{1000}$ gold and $\frac{2}{1000}$ silver? How much copper will be consumed by this operation?
12. What amount of gold, silver, and blue vitriol may be obtained by the refining of old silver coins in quantities of—
 - a.* 150 g, *b.* 200 Kg, *c.* 30 g?
 The gold amounts to 0.002, the silver to 0.9. How much copper will be consumed?

13. If a copper sheathing is laid in a solution of silver, after separation of the silver precipitated thereon it has become—
- | | |
|-------------------|------------------|
| <i>a.</i> 63.4 g, | <i>c.</i> 5 g, |
| <i>b.</i> 10 g, | <i>d.</i> 2.5 g, |
- lighter; how much silver nitrate was then contained in the solution?
14. Copper sheathing is laid in different solutions of silver chloride and common salt. After the precipitation of all the silver, the sheathings, with the silver precipitates, weigh—
- | | |
|--------------------|-------------------|
| <i>a.</i> 15.26 g, | <i>c.</i> 1.09 g, |
| <i>b.</i> 0.763 g, | <i>d.</i> 2.18 g, |
- more than before. How much silver chloride does each of the four solutions contain?
-

XXIV.—TIN.

1. How much tin and HCl are required to yield stannous chloride as follows:—
- | | |
|---------------------|---------------------|
| <i>a.</i> 225 lbs., | <i>d.</i> 100 g, |
| <i>b.</i> 75 Kg, | <i>e.</i> 100 lbs.? |
| <i>c.</i> 5 g, | |
2. How much of a muriatic acid containing $\frac{1}{3}$ of the acid is needed for the same purposes?
3. How many cu dm of chlorine must be conducted over tin as follows, to convert the same into stannic chloride:—
- | | |
|-------------------|------------------|
| <i>a.</i> 118 g, | <i>c.</i> 5.9 g, |
| <i>b.</i> 2.95 g, | <i>d.</i> 5 g? |
4. From how much black oxide of manganese and HCl must the chlorine be evolved to change—
- | | |
|-------------------|------------------|
| <i>a.</i> 118 g, | <i>c.</i> 5.9 g, |
| <i>b.</i> 2.95 g, | <i>d.</i> 5 g, |
- of tin to stannic chloride?

5. How much tin ore, containing 9 per cent. tinstone, is required to yield—
a. 100 lbs., *b.* 1000 cwt., *c.* 500 Kg,
of tin?
6. What per cent. of tin do two alloys contain of which—
a. 3.02 g, *b.* 2.5016 g,
by treating with nitric acid, after heating, give—
a. 1.9198 g, *b.* 0.795 g,
of a residue?
7. The tin is precipitated as sulphide from a liquid amounting to 26.54 g and this is converted by roasting into oxide. 4.3978 g are obtained from this. What per cent. of stannous chloride does this liquid contain?
-

XXV.—ANTIMONY.

1. What per cent. of antimony do two alloys contain of which every 2.5402 g, by treating with nitric acid, give—
a. 0.797 g, *b.* 0.836 g,
of antimonious acid?
2. How much antimonous sulphide is employed in the operation to obtain, by heating with sodium and sulphur, first sodium sulph-antimonate (Schlippe's salts, $\text{SbS}_4\text{Na}_3 + 9 \text{H}_2\text{O}$), and then, by the addition of an acid, the following quantities of antimonious sulphide:—
a. 404 g, *c.* 10.1 lbs.,
b. 50.5 g, *d.* 1 g?
3. What quantity of antimonous chloride and sodium carbonate are required to yield—
a. 292 g, *b.* 14.6 g, *c.* 1 lb.,
of antimonious oxide? What bye-products will be obtained, and how much?

4. How much Schlippe's salt (Vid. 2.) and muriatic acid of 20 per cent. of contents are necessary to yield golden sulphuret (Mosaic gold) as follows:—
- | | |
|----------------------|------------------|
| <i>a.</i> 404 g, | <i>c.</i> 1 g, |
| <i>b.</i> 10.1 lbs., | <i>d.</i> 100 g? |
5. What amount of sulphuric acid instead of the muriatic is used, if it still contains $\frac{1}{2}$ molecular weight of water, in addition to its water of hydration?
6. What per cent. of antimony must be obtained by theory from the melted gray antimony?
7. In what proportion must iron and the sulphide of antimony be heated together in obtaining antimony?
-

XXVI.—ARSENIC.

1. How much sulphur and arsenic must be melted together to obtain—
- | | |
|---------------------|---------------------|
| <i>a.</i> 214 g, | <i>c.</i> 100 lbs., |
| <i>b.</i> 107 lbs., | <i>d.</i> 1 Kg, |
- red sulphur of arsenic (Realgar)?
2. How much sulphur must be melted with arsenic to obtain yellow arsenic as follows:—
- | | |
|---------------------|-----------------|
| <i>a.</i> 246 g, | <i>c.</i> 41 g, |
| <i>b.</i> 123 lbs., | <i>d.</i> 1 Kg? |
3. What amount of arsenious acid do four liquids contain from which the following amounts of arsenic sulphide may be precipitated by means of hydrogen sulphide:—
- | | |
|-------------------|--------------------|
| <i>a.</i> 1.23 g, | <i>c.</i> 2.46 g, |
| <i>b.</i> 4.1 g, | <i>d.</i> 3.011 g? |

PART SECOND.

XXVIII.—APPROXIMATE RATIOS.

The correct approximate proportions of necessary materials are to be computed in the following examples:—

1. Preparation of hydrogen from zinc and sulphuric acid.

Solution ; Original relation 65 : 98. Since this ratio did not admit of simplification, 1 was added to the first term and it stood 66 : 98 or 33 : 49. Each term was now diminished by 1, so that it would stand 32 : 48 or 2 : 3.

Proof : 65 : 97.5.

2. Preparation of chlorine from manganese di-oxide and HCl.
3. Preparation of oxygen by means of black oxide of manganese and sulphuric acid.
4. Preparation of chlorine from manganese di-oxide and muriatic acid containing 41.858 per cent.
5. Preparation of caustic potash. Relation of burnt lime to potassium carbonate.
6. Preparation of soda from crystallized sodium sulphate, etc.
7. Preparation of ammonia from sal-ammoniac and un-slaked lime.
8. Preparation of barium carbonate from barium sulphate and potassium carbonate.
9. Preparation of nitric acid from powdered saltpeter, and a sulphuric acid containing 13.531 per cent. excess of water.
10. Preparation of potassium chlorate by means of potassic hydrate, black oxide of manganese, and HCl.

XXIX.—TEMPERATURE AND ATMOSPHERIC PRESSURE.

1. How many cu m of oxygen may be obtained from 1 Kg of potassium chlorate, if the gas be measured at a temperature of 18°C .?
2. What volume in cu cm would the explosive gas evolved from 1 cu cm of H_2O occupy when ignited, if it be free to expand, and it be granted that the coefficient of expansion be constant, and the temperature of the ignited gas amount to $12,000^{\circ}\text{C}$.?
3. If water absorbs 600 times its volume of ammonia gas, what is then the volume of the gas at 120°C ., which has been taken up by ten pounds of water?
4. How much is the volume of carbonic acid, at 15° and 750 mm pressure, which can be evolved from 4 Kg 480 g calcium carbonate?
5. What is the relation between the volume of air that must be mixed with the sulphurous acid arising from 10 g of sulphur, in order to yield the oxygen necessary for the formation of sulphuric acid and that of the sulphurous acid itself? The gases are to be compared at 748 mm, and 12° for the air, and 120° for the sulphurous acid. (Oxygen = 0.21 of air.)
6. By an organic analysis 1.0152 g of a substance gave 40.72 cu cm of nitrogen, measured at 12° and 730 mm pressure. What per cent. of nitrogen does the substance contain?
7. What amount of calcium carbonate would be required for 73.24 cu m of carbonic acid, measured at 730 mm pressure and 100°C .?
8. When water at 0° and 760 mm pressure absorbs 33 times its volume of sulphurous acid, the volume of this gas is to be calculated, which 5 Kg of water can take up, if the gas in the apparatus has a medium temperature of 82.8°C ., and the liquid columns of the apparatus, with a barometric height of 758 mm,

exert a pressure equal to that of 5 mm of mercury. No account is taken of the expansion of the water which takes place at 10° .

XXX.—MIXED PROBLEMS.

1. How long will a Doberneier lamp continue in operation before (1) the sulphuric acid, (2) the zinc must be renewed, if the same be supplied with 135.926 g of sulphuric acid, and 90.155 g of zinc; and if 86 cu cm of hydrogen be consumed daily?
2. What is the answer for the above if 200.9 g of sulphuric acid be taken and 139.776 g of zinc, and if 100 cu cm of hydrogen be consumed daily?
3. How much zinc, sulphuric acid, and potassium chlorate are required for two hours' exhibition of the Drummond light, if there is an average consumption per minute of 324 cu cm of oxy-hydrogen gas?
4. It is required to saturate 3300 lbs. of water with CO_2 . It is accomplished by a pump with a force of 6 atmospheres. How much sulphuric acid with $\frac{1}{2}$ the molecular weight of water, in addition to its hydrate, and how much (pure) marble are necessary?
5. It is required to obtain 509 Kg 856 g of water containing CO_2 , and the carbonic acid pressed in with 10 atmospheres. How much water, calcium carbonate, and sulphuric acid are needed?
6. In determining the CO_2 in gases, making two estimations daily, 50 cu cm of gas are used in each determination. Of this volume, 20 per cent. at the highest were found to be CO_2 ; *i. e.*, the amount absorbed by caustic potash, which, too, must be employed here in the least possible quantity. How much potassium hydrate would be consumed annually?

7. Under like conditions, as those of Prob. 6, we are to calculate what must be the least length of a cylindrical piece of fused potash employed. 100 cu cm of gas are tested each time, of which, on an average $\frac{1}{5}$ is absorbed. Owing to the water contained in the potash $\frac{1}{4}$ more than the necessary amount of it is taken. The diam. of the stick is 6 mm, spec. grav. 2.1.
8. It is desired to obtain 4 Kg 15.232 g of H_2O saturated with H_2S . The water takes up 2.5 times its volume of this gas. How many liters of H_2O , how many grams of sulphuric acid, and how much sulphide of iron are necessary?
9. How many liters of water, Kg sulphide of iron and sulphuric acid are necessary to yield 10 Kg of hydrogen sulphide water?
10. What per cent. of foreign substance does a diamond contain, of which, 0.0145 g gave as much gas in burning as would, with lime water, give a precipitate amounting to 0.12 g?
11. What quantity of calcium carbonate must you obtain by the absorption of the carbonic acid originating from the burning of 0.0063 g of diamond?
12. As the gas originating from the burning of a diamond of unknown weight is collected with the surplus oxygen over mercury, the volume of the obtained gas was diminished 5.52 cu cm by adding caustic potash. (Reckoned with normal temperature and normal pressure). What did the consumed part of the diamond weigh?
13. 100 g of pure potassium carbonate are obtained by the heating of potassium acetate. The latter should be obtained by means of neutral lead acetate. What must be done?
14. What per cent. of hydrochloric acid gas must a commercial muriatic acid contain, of which 6 g exactly suffice to dissolve $1\frac{1}{2}$ g of pure calcium carbonate?

15. What per cent. of hydrochloric acid gas does commercial muriatic contain, of which, 15 g are needed to neutralize 10.245 g of a potassium solution which contains 48 per cent. of hydrate?
16. For the determination of chlorine by means of a tenth silver solution ($\frac{1}{10}$ AgNO₃ in grams dissolved 1000 cu cm water) 300 cu cm of water were used and the final reaction reached, after the consumption of 0.55 cu cm. How much *a.* chlorine, *b.* sodium chloride does the water contain in 1000 parts?
17. 25 cu cm of water served for the determination of nitric acid by means of titrated indigo solution. This was standardized so that 6.5 cu cm were equal to 0.001 g of nitric acid. The blueing set in after 2.2 cu cm of the indigo solution were added. How much nitric acid is contained in 1000 parts water?
18. For the determination of the lime contained in a limestone, it can be dissolved in muriatic acid, the lime precipitated as oxalate, the precipitate dissolved in dilute sulphuric acid, and the oxalic acid in the solution determined by a standard solution of permanganate of potash in water. The latter is so standardized that 1 cu cm of the same corresponds to 0.0063 g of oxalic acid (*i. e.*, $\frac{1}{1000}$ C₂H₂O₆). By 1 g of limestone one liter was obtained; and for 100 cu cm of this, 18.2 cu cm of the permanganate solution were required.
What per cent. of calcium carbonate did the limestone contain?
19. 100 cu cm of an alkaline liquid of 1.102 spec. grav. should be mixed with normal nitric acid ($\frac{1}{1000}$ HNO₃) till the alkali reaction disappears and 5.3 cu cm are consumed for this. What will be the percentage, computed by this means, of—
 - a.* lime (calcium oxide),
 - b.* potassium (potassium oxide),
 - c.* ammonia (NH₃) ?

20. 100 cu cm of a liquid, which contained free acid and possessed a spec. grav. of 1.1 were titrated with normal soda ($\frac{1}{1000}$ NaOH) and consumed 6.1 cu cm of this.

What is the percentage, computed by this means, of—

- a. sulphuric anhydride,
- b. nitric anhydride,
- c. hydrochloric acid?

21. 5.3 g of calcined soda were dissolved in water and supersaturated with 100 cu cm of normal sulphuric acid ($\frac{1}{1000}$ H_2SO_4). After the expulsion of the carbonic acid by boiling, it was colored with litmus and retitrated with barium hydrate. By this means 45.6 cu cm of the latter were consumed, while a preceding experiment has shown that 10 cu cm of a normal sulphuric acid would exactly neutralize 66.6 cu cm of the barium solution. What per cent. of sodium carbonate did the calcined soda contain?

22. By the analysis of a bone charcoal, 100 lbs. of the same were found to yield—

10.2 lbs. of calcium carbonate,
63.2 lbs. of “ phosphate.

What per cent. of the weight of this bone charcoal, in sulphuric acid of 60 per cent., is exactly necessary for the décomposition?

23. A stick of marble weighed 10 g; it was placed in vinegar which, with a spec. grav. 1.0334 occupied a volume of 15 cu cm. After the evolution of gas had ceased, the stick of marble still weighed 8.698 g. What per cent. of acetic acid ($\text{C}_2\text{H}_4\text{O}_2$) did the vinegar contain? (1 molecule of calcium carbonate requires 2 molecules of acetic acid for saturation.)
24. What weight is able to keep up a spherical air balloon in equilibrium, which has a diam. of 4 m, is filled with hydrogen, and the covering of it weighs 5.31 Kg? Temperature 0° and normal pressure are

- taken, and the spec. grav. of the air = 14 times that of hydrogen.
25. In a known quantity of ashes are 62.7 g of potassium and sodium. Both oxides were converted into sulphates, and of this 122.8223 g obtained. What per cent. of potassium and sodium did that quantity of ashes contain?
 26. In a quantity of silicate amounting to 5.2 g, 1.9 g of potassium and sodium are found. From this the sulphuric acid salts are produced, and of these, 3.7182 g obtained. What per cent. of potassium and sodium does the silicate contain?
 27. A substance weighs 10.4 g. The quantity of potassium and sodium contained in it amounts to 1.9 g. From this 3.7182 g sulphates were obtained. What per cent. of potassium and sodium carbonate may be obtained from these for that substance?
 28. In what relation must the price of the pure caustic potash stand to that of the pure caustic soda, if, as regards the cost of the articles, it is immaterial which of the two should be used?
 29. How must the price of potassium carbonate proportion itself to that of the crystallized sodium carbonate, if the advantage shall arise from the employment of the latter?
 30. In a large laboratory, where the necessary caustic potash is made from the carbonate, there is an average annual consumption of 60 lbs. pure carbonate. The question arises, what advantage will there be in the use of carbonate of sodium? The price of the first is 50 cts.; that of the latter (crystallized) 15 cts. a kilo.
 31. How many cu dm of copper may be obtained by laying 154.579 cu dm of iron, spec. grav. 7.6, in a blue vitriol solution containing 20 per cent. of anhydrous salts, if it be granted that the separated copper will be re-melted and have a spec. grav. of

- 8.7? How many pounds of the original solution were decomposed for this?
32. What does a pound of lunar caustic cost, if, in its production, a 25 ct. piece of silver and an acid of 45 per cent. anhydride (price 25 cts. a kilo) are used? The additional expenses are regarded as covered by the obtained copper. (The weight and the quantity of the 25 ct. piece, see silver XXIII, 5.)
33. How much silver in an alloy, of which 119.904 g, treated with nitric acid, give 157.4 g of lunar caustic?
34. How much manganese di-oxide is necessary to yield 1 cwt. of potassium chlorate, if it be granted that 35 per cent. of the chlorine is lost in the operation?
35. How much carbonic acid may be obtained from 110 lbs. of limestone, which contains 31 per cent. gangue?
- What quantity of sulphuric acid is required for this?
36. What amount of—
- a. hydrochloric acid,
 - b. muriatic acid 55 per cent. of H_2O
- are necessary for this?
37. What amount of carbonic acid may be obtained from 25 Kg of a limestone, which contains 30 per cent. of magnesium carbonate?
38. How much common salt with 3 per cent. of magnesia sulphate, is necessary to obtain 110 lbs. of muriatic acid containing 28 per cent. hydrochloric acid gas, and how much sulphuric acid containing 4 per cent. surplus water is employed for this?
39. What per cent. of hydrochloric acid will a nitric acid contain which is made from potassium nitrate that contains 12 per cent. of sodium chloride? The calculation must be made with the hydrate HNO_3 .
40. How much sulphuric acid is necessary, with 45 Kg of this salt-peter?

41. How much H_2O must be employed in the manufacture of 100 lbs. of nitric acid, if the acid to be obtained shall contain 32 per cent. of H_2O , and the sulphuric acid be mixed with so much H_2O that it will contain 8 per cent. H_2O in addition to the hydrate?
42. How much saltpeter with 7.5 per cent. common salt, and how much sulphuric acid with 8 per cent. foreign materials are necessary, not acting in the decomposition, to yield 1000 lbs. of an aquafortis containing 18 per cent. of the contents of anhydrate?
43. We have solid nitrogenous substances containing 15 per cent. of nitrogen, and these are mixed with half their weight of liquid nitrogenous substances containing 2 per cent. of nitrogen. It is required to obtain saltpeter from this; the question becomes,
a. What is the least amount of lime (CaO) that must be mixed with 1000 Kg of the mixture, and how much potassium carbonate is needed to convert the obtained lime into potassium nitrate? *b.* How much potassium nitrate will be obtained if it be granted that 22 per cent. of nitrogen is lost?
44. How much zinc containing 5.712 per cent. of lead, and sulphuric acid containing 20 per cent. H_2O (besides the hydrate) are necessary to yield 11.16 cu dm hydrogen?
45. How would the requirements of the preceding example stand if muriatic acid containing 23 per cent. of hydrochloric acid should be employed?
46. A vitriol which may contain 2 parts green vitriol, 3 parts blue vitriol, and besides this still 12 per cent. of the whole weight of foreign materials shall be employed for obtaining cementation copper. How much of this and how much iron containing $2\frac{1}{2}$ per cent. of a carbonate are to be taken to yield 100 g of copper?
47. 1000 Kg of very concentrated Nordhausen vitriol

are to be obtained, which may contain in the whole 9 per cent. of H_2O . How much English sulphuric acid with 6 per cent. of H_2O besides the hydrate is necessary to take up the sulphuric acid, and how much sulphur residue (Fe_7S_8) must be roasted when the green vitriol is de-hydrated and converted into basic ferric sulphate?

48. Calculate the quantities of raw material, according to theory, necessary to yield 1000 Kg of ferro-cyanide of potash. A mixture of nitrogenous substances must be used which contains, on an average, 12.5 per cent. of nitrogen, 0.75 per cent. iron, and $2\frac{1}{2}$ per cent. potassium carbonate. The added potash has 8 per cent. of impurities.
49. With how much manganese di-oxide, containing 22 per cent. of foreign matter, is one able to evolve the most chlorine in order to obtain nitrogen by conducting it through 64 g of an ammonium solution, which may contain 18 per cent. of ammonium oxide, without forming nitrogen chloride?
50. Wanted, the quantities of sulphuric acid and carbon which exactly suffice to yield 10.64 cu dm of sulphurous acid; the sulphuric acid contains 3 per cent. salts, and of liquid parts still 4.124 per cent. of H_2O (besides the hydrate); the carbon contains 7.5 per cent. of salts.
51. A limestone contains 6.5 per cent. silicic acid. What portion is dead burnt by too high heat? What per cent. of H_2O is required for the slaking of this lime—
 - a. if it be well burnt,
 - b. when it is dead burnt?

It is granted, that in the resulting silicate, the oxygen of the silicic acid bears the ratio to the base 3 : 1.

52. What is the percentage composition of gunpowder if it be granted that the charcoal contains just 92 per cent. C, the saltpetre 0.15 per cent., the sulphur 1.05 per cent. of impurities?

53. What amount of lead oxide and calcium carbonate and sulphuric acid are necessary to obtain 1 lb. of white lead, if it is only desired to make sugar of lead, and we do not wish to dissolve the lead oxide more than once in it; and if it be granted that the neutral salt was precipitated?
54. The copper is to be obtained from 2 lbs. copper sulphide and may be done: (1) by roasting, dissolving, and precipitating with iron; (2) by roasting, dissolving, and precipitating with potassium, heating and reducing the oxide with hydrogen. The question is now—
 - (For 1). *a.* How much copper may be obtained?
 - b.* How much iron is used?
 - c.* How much crystallized green vitriol may be obtained?
- (For 2). How much zinc is consumed to yield the necessary amount of hydrogen?
55. How much barium sulphide and sodium carbonate are necessary to produce the quantity of barium carbonate, which, decomposed by acetic acid, exactly suffices to convert 3.54 g of potassium sulphate into acetate, and how much potassium carbonate will be obtained if this be heated?
56. How much mercuric sulphide must be distilled with lime to obtain that quantity of mercury which, after its oxidation with nitric acid and conversion into oxide, is exactly sufficient to furnish 5.33 g of oxygen?
57. A soda manufactory is combined with a manufactory of English sulphuric acid, which shall exactly cover the consumption of the soda manufactory. In the latter 1000 cwt. of crystallized soda are produced monthly. What is the monthly consumption of iron pyrites for the sulphuric acid, if sulphur is first obtained from the same and this shall then be burnt?

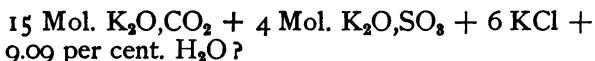
58. How much chrome-iron must be employed in the operation to obtain exactly the necessary quantity of neutral potassium chromate which is necessary to furnish 20 Kg of lead chromate?
59. It is required to furnish 100 g of assay-lead from red-lead. This is treated with nitric acid, the obtained salts heated, the oxide dissolved in acetic acid and zinc suspended in the solution. How much red-lead must be employed in the operation? The red-lead is taken as Pb_4O_6 .
60. Calomel is to be furnished from a quantity of mercury amounting to 40 g. The mercuric nitrate is precipitated with potassium, the oxide dissolved by sulphuric acid, and then proceed according to XXI., 2. How much calomel can be obtained, and is the whole amount of mercury dissolved in nitric acid, or what portion of it?
61. It is desired to obtain 168.5 g of chromic oxide, and for this di-potassium chromate is employed. The question is, how much of it is to be treated with sulphuric acid and alcohol?
62. How much cryolite is required to yield 1000 Kg of soda, if a loss of 5.51 per cent. is sustained?
63. How much alum will be obtained as bye-product, if the same, not pure, be reckoned with 5.12 per cent. of foreign salt?
64. What amount of potassium carbonate must be precipitated with tartaric acid in order to yield the tartar for the furnishing of 100 g of tartar emetic?
65. How much pure heavy spar must be heated with carbon in order to obtain as much barium sulphide, as, decomposed with HCl, and then precipitated with alkali carbonate, gives just as much barium carbonate as is necessary to yield 20 g of anhydrous barium acetate?
66. For the yielding of potassium iodide, heavy spar is converted into barium sulphide, the sulphur in this

- is precipitated with iodine, and the obtained barium iodide with potassium sulphate. What is the consumption of heavy spar and potassium sulphate, if 25 g of potassium iodide are obtained? How much potassium iodide can be obtained as by-product by means of the precipitated barium sulphide in a subsequent similar operation?
67. In order to produce chrome-alum, sulphurous acid can be conducted into acid potassium chromate saturated with sulphuric acid. What is the necessary proportion? (Or, what is the corresponding formula?)
68. For the yielding of ammonium sesqui-carbonate, a liquid containing 10 per cent. of ammonia (NH_3) will be saturated with muriatic acid, the obtained sal-ammoniac is distilled with calcium carbonate. The question becomes: (1) How much muriatic acid, containing 24 per cent. of acid contents, is needed to yield 100 lbs. of ammonium sesqui-carbonate? (2) What is the formula of the latter process from which the necessary quantity of lime can be calculated? It is known that ammonia will be liberated by the distillation.
69. In the preparation of potassium ferri-cyanide, a manganese di-oxide was employed, for the evolution of chlorine, very nearly free from iron. It is desired to precipitate the manganous chloride with potassium carbonate, and with the resulting manganous hydrate to precipitate the ferrous oxide from a solution of manganous chloride containing iron. 50 g of ferro-cyanide are converted into ferri-cyanide; how much ferrous oxide can be precipitated with the manganous hydrate obtained in this way?
70. When iodine is mixed with potassium hydrate, potassium iodate and iodide result. If this mixture be ignited, only potassium iodide is formed. The question then is: (1) What are the formulæ for

- both processes? (2) How much iodide of potassium may be obtained from 100 g of iodine? (3) What bye-products arise and how much?
71. An alum shale contains 6 per cent. of iron pyrites. It is found after the trial is made, that to 10 per cent., the whole amount of sulphuric acid arising from roasting combines with alumina and the potassium present, while that 10 per cent. forms basic ferric sulphate. The question is: How much potassium sulphate must be added to the lye of 1000 lbs. of the shale, if it be known that the ashes of the same contain 1.5 per cent., of the whole weight of the crude shale, potassium carbonate, which will be converted into potassium sulphate by the sulphuric acid already formed?
 72. What profit do 1000 cwt. of shale afford, by the foregoing relations in 71, if 20.06 per cent. is deducted for loss?
 73. A mother liquor contains 5 per cent. of sodium iodide; what per cent. of iodine is obtained from this? What per cent. of black oxide of manganese is necessary, if the same contains 98 per cent. of manganese peroxide, and how much muriatic acid containing 15 per cent. of the acid contents is needed? All the answers should be in per cent. of the mother liquor.
 74. A chrome-ore contains 45 per cent. of chromic iron. What per cent. of the same may be obtained in impure mono-potassium chromate, if this be mixed with 12 per cent. of potassium sulphate?
 75. A sample of mercury contains 3 per cent. of tin and 5 per cent. of lead. 10 Kg of mercurous nitrate are to be obtained. What quantity of mercury and how much 30 per cent. nitric acid are to be used, and by how much sulphuric acid can the dissolved lead oxide be precipitated?
 76. A laundry requires daily 10 Kg of potash with a
-

content of 5 per cent. water and 12 per cent. salts, at \$7.50 for 50 Kg. Instead of the same, partially disintegrated soda with 2 per cent. foreign salts, at \$3.75 for 50 Kg, is employed. What will be the difference in cost for ten days?

77. How much sulphuric acid, with 87 per cent. water in addition to the hydrate, is necessary in order to expel all the carbonic acid and muriatic acid from 12 g of potash, which is combined in the following manner:—



78. What is the percentage composition of a quantity of potassium chloride and sodium chloride, which increases in weight by heating with sulphuric acid to the amount of 19.2 per cent.?

79. What amount of potassium di-chromate, how much alcohol containing 85 per cent. by weight, and how much sulphuric acid with 5 per cent. of surplus H_2O are necessary to yield 5 lbs. of chromium potassium alum?

80. How much potassium permanganate is contained in a liter of a solution of which 55 cu cm are needed to oxydize 0.1 g of oxalic acid?

81. What is the atomic weight of a metal of which—

- a. 56 g with 98 g of sulphuric acid,
- b. 7 g " 12.25 g "
- c. 5.0 g " 3.2581 g HCl,

form a neutral salt after oxydation?

82. What is the atomic weight of a metal of which—

- a. 108 g dissolve if it be precipitated with 63.4 g of copper,
- b. 54 g dissolve if it be precipitated with 31.7 g of copper,
- c. 5 g dissolve if it be precipitated with 2.9352 g of copper?

83. The analysis of a substance which is known to be a chemical compound gave—

lime.....	30.434
magnesia.....	21.740
carbonic acid.....	47.826
	100.000

What is the formula of the substance?

84. The atomic weight of fluorine is to be found, when it is known that 100 parts of calcium fluoride treated with sulphuric acid gave 174.4 parts sulphate of lime, and that the calcium fluoride is analogously constituted to the calcium fluoride.
85. A compound consists of ferric and ferrous oxide. 5.256 g of it become converted into oxide by dissolving in nitric acid and then precipitating with ammonia; 5.478 g of ferric oxide are obtained. What is the percentage composition of the ore?
86. A ferrous-ferric oxide is reduced by hydrogen. The following is known :—
 the quantity of water 1.599 g, and
 that of the substance 5.256 g;
 Or :—
 the quantity of the water and obtained iron 3.8346 g;
 Or :—
 the quantity of the substance and the obtained iron.
 The composition of the substance is required.
87. What is the approximate formula of the investigated compounds in numbers 85 and 86?
88. What is the formula of a material of which the percentage composition is as follows :—

alumina.....	15.57
sulphuric acid.....	35.82
water.....	48.61
	100.00 ?

89. What is the formula for the mineral :—

silicic acid.....	64.70
alumina.....	18.50
potassium	16.80
	100.00?

90. In order to determine the carbon in a sample of iron, 7.584 g were treated in a flask with HCl, and the resulting mixture of hydrogen and hydrocarbon conducted through a heated tube containing cupric oxide. After collecting the water that was formed in a calcium chloride tube, the carbon di-oxide was absorbed in a vessel containing potassium hydrate. Before the determination the vessel weighed 46.531 g, afterwards, 46.7069 g. The substance remaining in the generating flask was thrown upon a filter, and the residual carbon repeatedly washed with HCl. The dried filter weighed alone 0.5622 g, and with the carbon 0.5841 g. What per cent. of carbon does the iron contain?
91. The following numbers are obtained from the examination of a combustible substance: 10 g weighed after drying 5.844 g; 1.505 g gave 0.1484 g of ashes. According to this what is the composition of the substance? What is the composition of the dry substance?
92. By a sugar examination 100 g furnish 95. g of sugar; furthermore a cup with sugar weighed 26.12 g, the cup alone 21.12 g; the cup with sugar after drying 26.01 g; further 2.113 g of sugar furnished 0.028 g of ashes. What is the composition of the sugar?
93. By the examination of a potassium salt 5.23 g were dried and its weight reduced to 5.10 g. Furthermore 10 g were dissolved to 1000 cu cm, and from 100 cu cm of this solution, after precipitation with barium chloride (to convert the alkali sulphate into chlorate) the potassium was precipitated by platinic chloride; 1.311 g of potassic platinic chloride

were obtained. The precipitate formed with barium chloride in the 100 cu cm solution weighed 0.917 g. Calculate the quantity of water contained in the salt, also the sulphates of sodium and potassium, assuming that only the alkalies are combined with sulphuric acid?

94. By the examination of a water the following numbers were obtained:—

1000 cu cm gave entire residue..... 0.693 g,
 1000 cu cm gave residue after ignition... 0.597 g,
 silicic acid found..... 0.0012 g,
 ferric oxide and alumina..... 0.0021 g.

The lime was precipitated by oxalic acid from 1000 cu cm, then dissolved to 1000 and 250 cu cm of this were titrated with a solution of (KMnO_4), of which 1.0 cu cm corresponded to 0.00286 g of lime. 26.9 cu cm were required.

By precipitating the magnesia from 1000 cu cm, 0.01293 g of pyro-phosphate of magnesia were obtained.

1000 cu cm gave a precipitate, with barium chloride, of 0.1536 g, and in the solution filtered off, 0.0107 g of chlorides were found.

1000 cu cm of the water required in the chlorine determination 1.833 cu cm $\frac{1}{10}$ silver solution of which 1 cu cm is equal to 0.00355 g of chlorine. How much of the various substances does the water contain in 100,000 parts?

95. Calculate the mineral constituents of the H_2O according to the results which were obtained in No. 94.

The chlorine is regarded as sodium chloride. If any chlorides still remain, these are considered as combined with sulphuric acid.

The sulphuric acid is to be considered combined with lime, the rest of the lime and magnesia are combined with carbonic acid.

96. The examination of a limestone afforded the following numbers for the dried substance :—

5. g left behind undissolved 0.1775 g. 100 cu cm of the nitrate solution of 5 g diluted to 500 cu cm gave a precipitate with ammonia of 0.0075 g.

1.45 g of limestone furnished in the carbonic acid apparatus 0.597 g of carbonic acid.

200 cu cm of the above solution yielded, after separation of the lime, 0.0299 g of magnesia phosphate. 200 cu cm of the same solution gave with barium chloride a precipitate of 0.0322 g.

0.06 g of potassium chloride were obtained from 100 g of limestone.

According to this what is the composition of limestone?

97. Calculate the analytical factors for the following proportions, *i. e.*, the numbers with which the quantities found must be multiplied in order to obtain the corresponding quantities of the substance sought.

FOUND.

- a. oxide of antimony,
- b. sulphide of arsenic,
- c. barium sulphate,
- d. barium sulphate,
- e. barium carbonate,
- f. lead oxide,
- g. plumbic oxide sulphate,
- h. sulphide of lead,
- i. calcium carbonate,

SOUGHT.

- antimony,
- arsenic acid,
- barium,
- sulphuric acid,
- barium,
- lead,
- lead,
- lead oxide,
- calcium.

98. Also the following :—

FOUND.

- a. ferric oxide,
- b. ferric oxide,
- c. calcium carbonate,
- d. cupric oxide,
- e. pyro-phosphate of magnesia,
- f. pyro-phosphate of magnesia,
- g. barium sulphate,
- h. water,
- i. zinc oxide,
- k. tin oxide,

SOUGHT.

- iron,
- ferrous oxide,
- carbonic acid,
- copper,
- magnesia,
- phosphoric acid,
- sulphur,
- hydrogen,
- zinc,
- tin.

99. How many cu cm of oxygen, reckoned with normal pressure and 20° C. are necessary to furnish the carbonic acid which will exactly answer for the production of 1000 Kg of a white lead containing 5 per cent. excess of water, and 25 per cent. of heavy spar; but in other respects corresponds to the formula $3 \text{ PbO}, \text{H}_2\text{O}, 2 \text{ CO}_2$?
100. What increase in volume does water sustain, if 500 times its volume of muriatic acid gas be dissolved in it, when the spec. grav. is increased to 1.21 (at 0°) by this operation?
101. How much black oxide of manganese, with 15 per cent. of foreign materials, is necessary to furnish the chlorine which converts 1 lb. of arsenious acid (anhydride) into arsenic acid (anhydride), if only $12\frac{1}{2}$ per cent. of the chlorine entered into the operation?
- What is the volume of the chlorine (under the normal relations)?

ANSWERS TO PROBLEMS.

PART FIRST.

OXYGEN.

1. 16 g.
2. *a.* 8 g. *b.* 4 g. *c.* 0.4 Kg. *d.* 0.08 Kg. *e.* 0.08 g.
3. 1.48 g.
4. 74.07 g.
5. *a.* 5 g. *b.* 50 g. *c.* 25 g.
6. *a.* 96 g. *b.* 48 g. *c.* 144 g. *d.* 0.96. *e.* 96 g.
7. (1) 200 g.
(2) *a.* 100 g. *b.* 50 g. *c.* 5 Kg. *d.* 1 Kg. *e.* 1 g.
(3) 18.52 g.
(4) 925.93 g.
(5) *a.* $62\frac{1}{2}$ g. *b.* 625 g. *c.* 312.5 g.
8. *a.* 149 g. *b.* 74.5. *c.* 223.5 g. *d.* 1.49 g. *e.* 149 g.
9. 3.918 g.
10. 39.18 per cent.
11. *a.* 391.8 g. *b.* 1 Kg 77 g, (1.77 Kg).
12. *a.* 1 g. *b.* 32 g. *c.* 0.3912 g.
13. (10) 60.82 per cent.
(11) *a.* 608.2 g. *b.* 1.67 Kg.
(12) *a.* 1.5521 g. *b.* 49.7 g. *c.* 0.608 g.
14. *a.* 32 g. *b.* 3.2 Kg. *c.* 320 g. *d.* 8 Kg. *e.* 80 g.
15. *a.* 73.56 lbs. *b.* 0.368 lbs.
16. 16 g.

17. *a.* 18.4 Kg. *b.* 0.184 lbs.
18. *a.* 9.2 Kg. *b.* 1.84 Kg. *c.* 5.33 g.
19. *b.* 16 g. *c.* 0.16 g. *d.* 3.2 Kg. *e.* 4 g. *f.* 64 Kg.
20. (16) 10.67 g.
(17) *a.* 12.26 Kg. *b.* 0.1226 lbs.
(18) *a.* 6.1 Kg. *b.* 1.226 Kg. *c.* 3.55 g.
21. *a.* 50 per cent. *b.* $33\frac{1}{3}$ per cent. *c.* $16\frac{2}{3}$ per cent.
22. $\times \frac{1}{2}$ or $\frac{1}{3}$.
23. 98 g.
24. 16 g. 151 g.
25. *a.* 49 Kg. *b.* 7 g. *c.* 56.32 Kg. *d.* 11.26 lbs.
26. *a.* 75.5 Kg. *b.* 10.8 g. *c.* 86.78 Kg. *d.* 17.35 lbs.
27. *a.* 216 g. *b.* 432 g. *c.* 324 g. *d.* 108 g. *e.* 54 g.
28. *a.* 13500 g. *b.* 27 g. *c.* 67.5 g. *d.* 135 g. *e.* 19.3536 g.
29. $\times 13.5$.
30. *a.* 245 g. *b.* 122.5 g. *c.* 367.5 Kg. *d.* 2.45 g. *e.* 0.245 Kg.
31. *a.* 2.55 g. *b.* 2552 g. *c.* 10 g. *d.* 1 g. *e.* 3.659 g.
32. 130.5 Kg.
33. *a.* 32.6 g. *b.* 1.305 g. *c.* 26.1 Kg.
34. *a.* 87 Kg. *b.* 100 Kg. *c.* 1 g. *d.* 50 Kg. *e.* 10 Kg. *f.* 29 g.
35. *a.* 87 g. *b.* 43.5 g. *c.* 21.75 Kg. *d.* 2.175 lbs.
36. *a.* 50.025 Kg. *b.* 10 Kg. *c.* 29 g. *d.* 100 g. *e.* 1 g. *f.* 543.75 g.
37. (35) *a.* 98 g. *b.* 49 g. *c.* 24.5 Kg. *d.* 0.245 lbs.
(36) *a.* 56.3 Kg. *b.* 11.27 Kg. *c.* 32.64 g. *d.* 112.7 g. *e.* 1.127 g.
f. 612.5 g.
38. *a.* 87 g, and 98 g. *b.* 108.75 lbs., and 122.5 lbs. *c.* 543.75 g, and 612.5 g. *d.* 5.437 Kg, and 6.125 Kg. *e.* 7.795 g, and 8.78 g.
39. 19.3536 g.
40. 29.0304 Kg.
41. *a.* 13.665 cu m. *b.* 2.733 cu m. *c.* 0.001 cu m.
42. 7.795 g, and 8.78 g.

HYDROGEN.

1. a. 2 Kg. b. 16 Kg.
H. O.
2. a. 1 Kg, 8 Kg.
b. 4 g, 32 g.
c. 3 g, 24 g.
d. 1 Kg, 8 Kg.
e. 9 Kg, 72 Kg.
f. 0.02 g, 0.16 g.
g. 2 g, 16 g.
h. 1 Kg, 8 Kg.
H. O.
3. a. $\frac{1}{9}$ Kg (III.III g), $\frac{8}{9}$ Kg.
b. 5.55 g, 44.44 g.
c. III $\frac{1}{9}$ g, 888 $\frac{8}{9}$ g.
d. 27.78 g, 222.22 g.
4. a. 2 g. b. $3\frac{1}{3}$ g. c. II.III g. d. I.I g. e. 33.33 g.
f. III.II g.
5. a. 16 g. b. $26\frac{2}{3}$ g. c. 88.89 g. d. 8.9 g. e. 266.67 g.
f. 888.89 g.
6. —
7. a. $\div 9$. b. $\times \frac{9}{10}$.
8. 2 g.
9. a. 1 Kg. b. 2.04 g.
10. a. No. The one is conditioned by the other. b. 35.5 g Z in excess.
11. 142.8 g ($\frac{1}{7}$ Kg).
12. 0.26 g.
13. a. 5.5 g. b. 9.18 g. c. 6.66 Kg. d. 0.8 Kg.
14. a. 1 l. b. 100 l. c. 1240 l.
15. 1860 l.
16. 1.860 l.
17. 1500 cu cm CH_4 . 0.8064 H_2O .
18. 98 Kg, H_2SO_4 . 65.2 Kg, Zn.
19. 81.7 g, H_2SO_4 . 54.3 g, Zn.
H₂SO₄. Zn.
20. a. 4.390 g, 2.921 g.
b. 439.0 g, 292.1 g.
c. 5.44 Kg, 3.62 Kg.

21. *a.* 27 g. *b.* 0.81 Kg. *c.* 40.5 g. *d.* 90 g. *e.* 80.64 g.
22. *a.* 24 g. *b.* 0.72 Kg. *c.* 36 g. *d.* 80 g. *e.* 71.68 g.
- H_2SO_4 . Zn.
23. *a.* 98 Kg, 65.2 Kg.
b. 4900 g, 3260 g.
c. 4.3904 g, 2.921 g.
d. 4 Kg 390.4 g, 2 Kg 921 g.
24. *a.* 0.8064 g. *b.* 0.08064 l. *c.* 80.64 Kg.
25. *a.* 43904 g, and 2.921 g. *b.* 0.439 Kg, and 0.292 Kg. *c.* 439 Kg, and 292 Kg.

CHLORINE.

1. *a.* 71 Kg. *b.* 71 lbs. *c.* 0.71 g.
2. *a.* 35.5 g. *b.* 3 Kg 550 g. *c.* 3.55 g.
3. *a.* 71 g. *b.* 710 g. *c.* 81.608 lbs. *d.* 16.322 g.
4. *a.* 25.66 cu dm. *b.* 15.29 cu dm.
5. *a.* 146 lbs. *b.* 73 g. *c.* 167.82 g. *d.* 1 Kg 678.16 g.
6. *a.* 87 g. *b.* 0.870 Kg. *c.* 297.94 g. *d.* 5.959 lbs. *e.* 10 g.
f. 1 Kg.
- MnO_2 . HCl.
7. *a.* 87 g, 146 g.
b. 43.5 lbs., 73 lbs.
c. 8.7 g, 14.6 g.
d. 50 Kg, 83.91 Kg.
e. 100 g, 167.82 g.
f. 59.59 g, 100 g.
- MnO_2 . HCl.
8. *a.* 500 g, 839.1 g.
b. 595.9 g, 1000 g.
c. 3.897 Kg, 6.54 Kg.
- H_2SO_4 . NaCl. MnO_2 .
9. *a.* 196 g, 117 g, 87 g.
b. 19.6 lbs., 11.7 lbs., 8.7 lbs.
c. 276.0 g, 164.8 g, 122.5 g.
- H_2SO_4 . NaCl. MnO_2 .
10. *a.* 8781 g, 524.15 g, 389.777 g.
b. 8.781 Kg, 5.241 Kg, 3.898 Kg.
11. 63.616 g.
12. 1 : 1.0063616.

13. 198.72 cu cm.
14. a. 73 lbs. b. 36.5 Kg. c. 7.3 g. d. 62.4 lbs. e. 623.93 g.
f. 0.624 g.
15. a. 73 lbs. b. 36.5 g. c. 3.65 g. d. 0.745 g. e. 186.22 g.
f. 74.49 Kg.
16. (14) a. 142 lbs. b. 71 Kg. c. 14.2 g. d. 121.36 lbs. e. 1213.6 g.
f. 1.2136 g.
- (15) a. 142 lbs. b. 71 g. c. 7.1 g. d. 1.44898 g. e. 362.24 g.
f. 144.898 Kg.
17. a. 117. g. b. 58.5 lbs. c. 0.836 g. d. 131.326 lbs. e. 1193.877 g.
f. 29.847 g.
18. H_2SO_4 . NaCl .
a. 98 lbs., 117 lbs.
b. 49 g, 58.5 g.
c. 1 Kg 342.4 g, 1 Kg 602.7 g.
d. 134.24 g, 160.27 g.
19. 1.6352 g.
20. 2 Kg 195.2 g, acid. 2 Kg 620 g, salt.
21. H_2SO_4 . NaCl .
a. 93.97 lbs., 112.19 lbs.
b. 1879.4 g, 2243.8 g.
c. 281.91 Kg, 336.57 Kg.
- H_2O . Na_2SO_4 .
a. $163\frac{1}{3}$ lbs., 136.16 lbs.
b. $3266\frac{2}{3}$ g, 2723.3 g.
c. 490 Kg, 408.48 Kg.
22. 39.54 per cent.
23. 7.56 per cent.
24. 176.45 cu cm.

NITROGEN.

1. 14.43.
2. 1293 g.
3. a. 0.001293. b. 773.
4. a. 0.90446. b. 1.03079.
5. 14.42 times.
6. 76.7 N. 23.3 O.
7. 1.2656 cu m. 295.3 g P.

NITRIC ACID.

8. 126 g.
9. *a.* 63 lbs. *b.* 12.6 g. *c.* 741.2 g. *d.* 6.3126 g. *e.* 1 Kg
260 g. *f.* 6.3 g.
10. 14.28 per cent.
11. $\frac{191}{180}$ or $6\frac{7}{9}$, also: *a.* 54 lbs. *b.* 10.8 g. *c.* 635.3 g. *d.* 5.4108 g.
e. 1 Kg 80 g. *f.* 5.4 g.
12. *a.* 27 lbs. *b.* 5.4 g. *c.* 317.65 g. *d.* 2.7054 g. *e.* 540 g.
f. 2.7 g.
13. 2000 g. 740 g, H_2O .
14. *a.* 98 Kg. *b.* 49 lbs. *c.* 4.9 g. *d.* 11.529 g. *e.* 576.47 g.
f. 6.92 g.
- | | | |
|-----|---|--|
| | Na_2NO_3 . | H_2SO_4 . |
| 15. | <i>a.</i> 170 g,
<i>b.</i> 85 lbs.,
<i>c.</i> 34 g,
<i>d.</i> 8.517 g,
<i>e.</i> 134.92 g,
<i>f.</i> 148.41 lbs.,
<i>g.</i> 1349.20 g,
<i>h.</i> 944.44 g, | 98 g.
49 lbs.
19.6 g.
4.9098 g.
77.77 g.
85.55 lbs.
777.77 g.
544.44 g. |
- | | | | |
|-----|--|---------------------|--------------------|
| | Salt peter. | Acid. | H_2O . |
| 16. | <i>a.</i> 425 lbs.,
<i>b.</i> 1700 g, | 245 lbs.,
980 g, | 135 lbs.
540 g. |
17. *a.* 60 lbs. *b.* 30 g. *c.* 0.139 lbs. *d.* 0.394 g. *e.* $\frac{5}{6}$ g.
18. *a.* 76 lbs. *b.* 38 g. *c.* 0.176 lbs. *d.* 0.5 g. *e.* $1\frac{1}{18}$ g.
- | | | |
|-----|--|----------------------------------|
| | Oxide. | Acid. |
| 19. | <i>a.</i> 7.5 lbs.,
<i>b.</i> 0.2083 Kg,
<i>c.</i> 0.52 g, | 9.5 lbs.
0.264 Kg.
0.66 g. |
20. *a.* 108 g. *b.* 27 g. *c.* 1.895 g.
21. $N = 82.353$. $H = 17.647$.
22. NH_3 , 31.8. HCl , 68.2.
23. 0.7616 g.
24. 0.5893. 0.0007616.
25. 1904. g. In ratio 1 : 1.38.
26. *a.* 17 g. *b.* 170 lbs. *c.* 158.878 g. *d.* 317.757 g.

27. 34 g.
 28. *a.* 17 g. *b.* $4\frac{1}{4}$ lbs. *c.* 0.60714 lbs. *d.* 607.14 g.
 29. *a.* 55.50 g. *b.* 13.875 lbs. *c.* 1.98 lbs. *d.* 1982.14 g.
 30. *a.* 56 g. *b.* 28 lbs. *c.* 0.523 lbs. *d.* 523.36 g.
 31. *a.* 107 g. *b.* 13.375 lbs. *c.* 1.9107 Kg. *d.* 1 lb. *e.* 1 Kg.
f. 110 g.
 32. *a.* 107 lbs. *b.* 53.5 g. *c.* 110 g. *d.* 1 Kg. *e.* 3.147 lbs.
f. 3147 g.
 33. *a.* 56 g. *b.* 28 lbs. *c.* 14 g. *d.* 1 g. *e.* 1000 lbs. *f.* 164.7 lbs.
 34. *a.* 3147.06 g, and 1647.06 g. *b.* 31.5 lbs., and 16.5 lbs.
 35. 16.777 Kg. 8.781 Kg.

SULPHUR.

1. 192 lbs. 648 lbs.
 2. *a.* 228.57 g, and 771.428 g. *b.* 228.57 lbs., and 771.428 lbs.
c. 8 g, and 27 g. *d.* 114.28 g, and 385.714 g.
 3. *a.* 840 g. *b.* 420 g. *c.* 4.375 lbs. *d.* 35 Kg. *e.* 110 lbs.
 4. 64 g.
 5. *a.* 2 g. *b.* 40 lbs. *c.* 100 Kg. *d.* 2 Kg. *e.* 10 g.
 6. 32. 1 liter weighs 2.8672 g, which contains 1.4336 g O.
 7. *a.* 0.6975 l. *b.* 6.975 l.
 8. *a.* 64 g. *b.* 6.4 lbs. *c.* 1 Kg 600 g. *d.* 1009.46 g. .
 9. *a.* 159.4 g. *b.* 15.94 lbs. *c.* 3. Kg 985 g. *d.* 2514.2 g.
 10. *a.* 128 g. *b.* 64 lbs.
 11. *a.* 128 lbs. *b.* 65.3 lbs. *c.* 48 g. *d.* 320 g.
 12. *a.* 44 lbs. *b.* 22.45 lbs. *c.* 16.5 g. *d.* 110 g.
 13. *a.* 196 lbs. *b.* 98 g.
 14. *a.* 3.091 g. *b.* 15.45 g. *c.* 31 lbs. *d.* 3091.48 g.
 15. *a.* 63.4 lbs. *b.* 1 g. *c.* 5 g. *d.* 10.027 lbs. *e.* 1 Kg.
 16. *a.* 12 g. *b.* 6 lbs. *c.* 1 lb. *d.* 110 g.
 17. 42.26 g.
 18. *a.* 22 g. *b.* 1 Kg 100 g. *c.* 8.594 lbs. *d.* 6.875 g.
 19. *a.* 98. *b.* 80. *c.* 16.
 20. *a.* 49 lbs. *b.* 7.656 lbs. *c.* 7 Kg 656 g. *d.* 306.25 g.
 G

21. *a.* Half. *b.* The whole.
22. (1) *a.* 196 lbs. *b.* 98 g. *c.* 30.625 lbs. *d.* 61.25 g.
 (2) *a.* 98 lbs. *b.* 49 g. *c.* 15.3125 lbs. *d.* 30.625 g.
23. *a.* 3 Kg 62.5 g, and 990.625 g. *b.* 306¼ lbs., and 99 lbs.
24. *a.* 1 Kg 531.25 g, and 93.75 g. *b.* 153¼ lbs., and 9¾ lbs.
25. 4390.4 g, and 268. g.
26. 878.1 g, and 284.032 g.
27. *a.* 80 lbs. *b.* 40 g. *c.* 1¼ lb. *d.* 1250 g.
28. *a.* 16 lbs. *b.* 8 g. *c.* ¼ lb. *d.* 250 g.
- | | | |
|-----|---------------------------|------------------------|
| | H_2SO_4 . | H_2O . |
| 29. | <i>a.</i> 98 lbs., | 18 lbs. |
| | <i>b.</i> 49 g, | 9 g. |
| | <i>c.</i> 765.625 g, | 140.625 g. |
| | <i>d.</i> 1531.25 g, | 281.25 g. |
30. (1) *a.* 80 lbs. *b.* 2½ lbs. *c.* 20 g. *d.* 2.5 g. *e.* 250 lbs.
f. 2 Kg 500 g.
- (2) *a.* 98 lbs. *b.* 3½ lbs. *c.* 24.5 g. *d.* 3.0625 g. *e.* 306.25 lbs.
f. 3 Kg 62.5 g.
31. *a.* $\times 2\frac{1}{2}$. *b.* $\times 1\frac{1}{4}$.
32. *a.* 2 Kg 500 g. *b.* 3.0625 Kg. *c.* 3.4028 Kg.
33. *a.* 64 g. *b.* 16 lbs. *c.* 800 g. *d.* 4 lbs. *e.* 9.068 g.
34. *a.* 64 g, & 18 g. *b.* 4.5714 lbs., & 1.2857 lbs. *c.* 4 lbs., & 1.125 lbs. *d.* 653.06 g, & 183.67 g. *e.* 9.6 Kg, & 2.7 Kg.
35. *a.* 16 g. *b.* 1.14287 lbs. *c.* 1 lb. *d.* 163.27 g. *e.* 2.4 Kg.
36. 5 cu m, O. 35.84 Kg, anhydride. 43.904 Kg, hydrate.
 8.064 l, H_2O .
37. 47.936 Kg.
- | | | |
|-----|--|---|
| | <i>a.</i> | <i>b.</i> |
| 38. | 98 Kg, hydrate. | 49 cwt., hydrate. |
| | 107 Kg, H_2O and acid. | 53.5 cwt., H_2O and acid. |
| | 48 Kg, O. | 24 cwt., O. |
| | 208.7 Kg, air. | 104.35 cwt., air. |
| | 18 Kg, H_2O . | 9 cwt., H_2O . |
| | 27 Kg, H_2O . | 13.5 cwt., H_2O . |
39. *a.* 3.0625 Kg. 1.0463 cu m, O. 5 cu m, air.
b. 306.25 lbs. 52.316 cu m, O. 250.3 cu m, air.

40. 34.88 cu m, O. 132.01 cu m, N, separated. $H_2O = 28.12$ Kg.
 Added O = 17.44 cu m. H_2SO_4 . a. 153.12 Kg.
 b. 167.18 Kg.
41. S = 326.5 Kg. O = 489.7 Kg.
 Air = 2102 Kg. $H_2O = 275.5$ Kg.
42. 94.11765 S. 5.88235 H.
43. a. 17. b. 1.5232 g.
44. SO_2 . H_2O .
 a. 64 g, 18 g.
 b. 32 g, 9 g.
 c. 640 g, 180 g.
 d. 3.765 lbs., 1.059 lbs.
45. a. 2867.2 g, SO_2 , or 1 cu m. b. 0.8064 l, H_2O .
46. 2150.4 g.
47. a. 34 g. b. 1 Kg 700 g. c. 8.5 g. d. 0.386 lbs. e. 139.5 g.
 f. 386.4 g.
48. a. 98 g. b. 4 Kg 900 g. c. 24.5 g. d. 1.1136 lbs. e. 402.13 g.
 f. 1113.7 g.
49. (1) a. 88 lbs. b. 361.1 g. c. 8.38886 lbs. d. 3942.4 g.
 (2) a. 98 lbs. b. 402.08 g. c. 9.34214 lbs. d. 4390.4 g.
50. a. 3.9424 g, and 4.3866 g. b. 985.6, and 1097.6 g.

PHOSPHORUS.

1. a. 62 g. b. 15.5 lbs. c. 0.87324 lbs. d. 2.183 g.
2. a. 30 lbs. b. 0.42253 lbs. c. 4.2253 g. d. 422.53 g.
3. P. CO_2 .
 a. 31 lbs., 70 lbs.
 b. 218.3 g, 492.96 g.
 c. 4.366 g, 9.859 g.
 d. 436.61 g, 985.91 g.
4. 295.8 g, P. 265.6 cu dm, O. 1.2656 cu m, Air.
5. a. 34 g. b. 17 g. c. 1.37 g. d. 2.74 g.
6. P. 91.18 l. H. 8.82.
7. a. 18 l. b. 6 l.
8. Lime. P. H_2O .
 a. 84 g, 124 g, 27 g.
 b. 24.7 g, 36.47 g, 7.94 g.
 c. 3.7632 g, 5.555 g, 1.217 g.

	Lime.	P.	H ₂ O.
9.	a. 3.7632 g, b. 940.8 g,	5.555 g, 1388.8 g,	1.217 g. 304.25 g.

CARBON.

	CO.	CO ₂ .
1.	28 g,	44 g.
	CO.	CO ₂ .
2.	a. 2 Kg 333.33 g, b. 583.33 g, c. 233.33 lbs., d. 0.28 g, e. 3.500 Kg, f. 700 g,	3 Kg 666.67 g. 916.67 g. 366.66 lbs. 0.44 g. 5.500 Kg. 1100 g.
	CO.	CO ₂ .
3.	a. 1 Kg 333.33 g, b. 333.33 g, c. 133.33 lbs., d. 0.16 g, e. 2 Kg, f. 400 g,	2 Kg 666.67 g. 666.67 lbs. 266.33 Kg. 0.32 g. 4 Kg. 800 g.
4.	Multiply by: a. $2\frac{1}{3}$. b. $3\frac{2}{3}$. c. $1\frac{1}{3}$. d. $2\frac{2}{3}$.	
5.	a. 1254.4 g. b. 1971.2 g.	
6.	1860.1 cu m, O. 8857.1 cu m, Air.	
7.	Half.	
8.	a. 1860.1. b. 1860.1.	
9.	a. 44 g. b. 440 g. c. 11 lbs. d. 0.44 g. e. 440 Kg. f. 100 Kg.	
10.	a. 5.3 g. b. 5.3 g.	
11.	6.7454 g.	
12.	a. 42.2 lbs. b. 843.83 g.	
13.	38 $\frac{3}{11}$ lbs. 8 $\frac{3}{11}$ lbs. lighter.	
14.	20.625 g, and 26.250 g.	
15.	a. 28 g. b. 28 g.	
16.	a. 44 g. b. 18 g, and 54 g, H ₂ O.	
17.	In both 280 g, or 223.2 cu dm.	
18.	a. 98 g. b. 9.8 lbs. c. 2.94 g. d. 147 Kg. e. 107.8 lbs.	
19.	a. 107 g. b. 10.7 lbs. c. 3.21 g. d. 160.5 Kg. e. 117.7 lbs.	
20.	a. 292 g. b. 29.2 lbs. c. 8.76 g. d. 438 Kg. e. 321.2 lbs.	

21. *a.* 12 g. *b.* 9 lbs. *c.* 34.2857 g. *d.* 0.42857 lbs. *e.* 0.2143 g.
f. 537.6 g.
22. 53.76 g.
23. *a.* 12 lbs. *b.* 6 g. *c.* 96 g. *d.* 537.6 g. *e.* 1 Kg 200 g.
f. 33.3 g.
24. *a.* 1000 Kg.
25. *a.* 365 g, and 245 g. *b.* 486.67 Kg, and 326.67 Kg.
26. 53.571 g, CaCO₃. 130.333 g, HCl. 6.428 g, C.
27. 4 Kg 480 g, and 4 Kg 793.6 g.
28. 17 Kg 920 g, and 17 Kg 561.6 g.
29. *a.* 64 g, nearly 12 g. *b.* 32 lbs., nearly 6 lbs. *c.* 4.21 lbs.,
nearly 0.79 lbs. *d.* 16.842 g, nearly 3.158 g.
30. 85.7 C. 14.3 H.
31. 75.0 C. 25.0 H.
32. 3 cu m.
33. 2 cu dm.

FLUORINE.

1. 95 Fl. 5 H.
2. *a.* 40 g. *b.* 20 lbs. *c.* 12.82 g. *d.* 512.8 g.
3. *a.* 111 $\frac{1}{9}$ lbs. *b.* 55.55 g. *c.* 13.889 g. *d.* 13.6 g.
4. *a.* 39 lbs., and 49 lbs. *b.* 19.5 g, and 24.5 g. *c.* 1.95 g, and
2.45 g. *d.* 58.5 g, and 73.5 g. *e.* 1 Kg 950 g, and 2 Kg
450 g. *f.* 1 lb., 475 g, and 2 lbs., 225 g.
- | | Fluorspar. | H ₂ SO ₄ . | H ₂ O. |
|----|-------------------------|----------------------------------|-------------------|
| 5. | <i>a.</i> 39 g, | 49 g, | 5 g. |
| | <i>b.</i> 54.6 g, | 68.6 g, | 7 g. |
| | <i>c.</i> 7.8 g, | 9.8 g, | 1 g. |
| | <i>d.</i> 1.56 g, | 1.96 g, | 0.2 g. |
| | <i>e.</i> 1 lb., 280 g, | 1 lb., 480 g, | 100 g. |
6. *a.* 136 g. *b.* 68 lbs. *c.* 3.4 g. *d.* 102 g.

POTASSIUM.

1. *a.* 112 lbs. *b.* 56 g. *c.* 811.6 g. *d.* 162.32 lbs.
- | | Unslaked Lime. | Slaked Lime. | Carbonate of Lime. |
|----|-----------------------|--------------|--------------------|
| 2. | <i>a.</i> 56 lbs., | 74 lbs., | 100 lbs. |
| | <i>b.</i> 28 g, | 37 g, | 50 g. |
| | <i>c.</i> 405.8 g, | 536.2 g, | 724.7 g. |
| | <i>d.</i> 81.16 lbs., | 107.2 lbs., | 144.9 lbs. |

- | | | |
|-----|---|---|
| | Burnt Lime. | Carbonate. |
| 3. | a. 56 lbs.,
b. $\frac{1}{2}$ lb.,
c. 12.5 g,
d. 405.8 g, | 138 lbs.
1.23 lbs.
30.8 g.
1 Kg. |
| 4. | a. 188 g. b. 376 lbs. c. 2.725 lbs. d. 2 Kg 724.6 g. e. 68.12 g. | |
| 5. | a. 6.48 g. b. 107.97 g. c. 10.8 lbs. d. 1 Kg 79.7 g. e. 26.99 g. | |
| 6. | — | |
| 7. | a. 1231.7 g. b. 14 cwt., 78 lbs. c. 12 cwt., 31.7 lbs. | |
| 8. | a. 841.4 g. b. 10 cwt., 9.7 lbs. c. 8 cwt., 41.4 lbs. | |
| | K_2CO_3 . | $CaNO_3$. |
| 9. | a. 138 lbs.,
b. 68.31 lbs.,
c. 841.4 g,
d. 10 cwt., 9.7 lbs.,
e. 683 cwt., 16 lbs., | 164 lbs.
81.17 lbs.
1000 g.
12 cwt.
811 cwt., 88 lbs. |
| 10. | 428.6 cwt., $CaCO_3$. | 865.7 cwt., Saltpeter. |
| | Nitrate. | Sulphate. |
| 11. | a. 109.77 lbs.,
b. 33.66 g, | 106.52 lbs.,
32.64 g, |
| | | Water. |
| | | 4.240 lbs.
1.3 g. |
| 12. | 533. g, Saltpeter. | 517.2 g, H_2SO_4 . |
| | | 667.5 g, Water. |
| 13. | 100 KNO_3 | 15.84 S. 17.82 C. |
| 14. | 74.82 KNO_3 . | 11.85 S. 13.33 C. |
| | K_2S . | N. |
| 15. | a. 40.74 lbs.,
b. 2.037 g, | 10.37 lbs.,
0.518 g, |
| | | CO_2 . |
| | | 48.89 lbs.
2.44 g. |
| | N. | CO_2 . |
| 16. | a. 4.13 cu m + 12.40 cu m = 16.53 cu m.
b. 0.413 cu dm + 1.240 cu dm = 1.653 cu dm. | Gas. |
| 17. | a. 302.48 Kg. b. 151.24 g. | |
| 18. | 28 N. 3.44 CO_2 . | |
| 19. | a. 213 lbs. b. 21.3 g. c. 0.634 lbs. d. 126.8 g. | |
| 20. | a. 495 lbs. b. 49.5 g. c. 1.473 lbs. d. 294.6 g. | |
| 21. | a. 122.5 lbs. b. 12.25 g. c. 0.364 g. d. 72.9 g. | |
| 22. | a. 75.25 parts. b. 3.04 parts. | |

- | | K. | MnO ₂ . | HCl. |
|-----|--|---|--|
| 23. | a. 336 g,
b. 2.743 lbs.,
c. 2742.8 g,
d. 54.8 lbs., | 261 g,
2.131 lbs.,
2130.6 g,
42.6 lbs. | 438 g.
3.575 lbs.
3575.5 g.
71.5 lbs. |
| 24. | a. 552 g. | b. 10.78 g. | c. 8.62 Kg. d. 107.8 lbs. |
| | S. | | CO ₂ . |
| 25. | a. 888 g,
b. 17.34 g,
c. 13.87 Kg,
d. 173.44 lbs., | | 176 g.
3.44 g.
2.75 Kg.
34.37 lbs. |
| 26. | a. 714 g. | b. 13.94 g. | c. 11.15 Kg. d. 139.4 lbs. |
| 27. | 80.4. | | |
| 28. | a. 15 times. b. $\frac{3}{4}$. | | |
| 29. | From 16 S, 17 $\frac{1}{4}$ K ₂ CO ₃ . | | |

SODIUM.

- | | | | |
|----|--|---|--|
| 1. | Na. | | |
| 2. | a. Na ₂ CO ₃ . b. K ₂ CO ₃ . | | |
| 3. | — | | |
| | Na. | CO ₂ . | H ₂ O. |
| 4. | a. 58.49,
b. 21.68, | 41.51.
15.38, | 62.94. |
| 5. | a. 318 lbs. b. 159 lbs. | c. 53 Kg. | d. 746.5 lbs. e. 746.48 Kg.
f. 52.25 cwt. |
| | CaCO ₃ . | | C. |
| 6. | a. 400 lbs.,
b. 200 lbs.,
c. 66 $\frac{2}{3}$ Kg,
d. 938.97 lbs.,
e. 938.967 Kg,
f. 65.73 cwt., | | 156 lbs.
78 lbs.
26 Kg.
366.2 lbs.
366.2 Kg.
25.63 cwt. |
| | Na ₂ SO ₄ . | CaCO ₃ . | C. |
| 7. | a. 426 lbs.,
b. 1000 Kg,
c. 1339.62 lbs.
d. 669 Kg 811 g, | 400 lbs.
938.97 Kg,
1257.8 lbs.,
628 Kg 930 g, | 156 lbs.
366.2 Kg.
490.56 lbs.
245 Kg 238 g. |
| | Crystallized Na ₂ SO ₄ . | CaCO ₃ . | C. |
| 8. | a. 966 lbs.,
b. 161 cwt.,
c. 1125.87 cwt.,
d. 122.59 Kg, | 400 lbs.,
66 $\frac{2}{3}$ cwt.,
466.2 cwt.,
46.62 Kg, | 156 lbs.
26 cwt.
181.2 cwt.
18.18 Kg. |

- | | Salt. | HCl. |
|-----|--|--|
| 9. | a. 351 lbs.,
b. 823.94 Kg,
c. 1103.77 lbs.,
d. 551.89 Kg, | 219 lbs.
514.08 Kg.
688.7 lbs.
344.34 Kg. |
| 10. | 110.37 Kg salt; 92.45 Kg H_2SO_4 ; 125.78 Kg, $CaCO_3$; 49.06 Kg, C; 68.87 Kg, HCl; 85.54 Kg basic, $CaSO_4$; 123.87 Kg CO_2 . | |
| 11. | ———— | |
| 12. | 265.7 cu cm. | |
| 13. | 11.16 cu dm. | |
| 14. | $3\frac{1}{2}$ to 1. | |
| 15. | 132.8 cu dm. | |
| 16. | 8 : 7. | |
| 17. | Na 16.23. $B(OH)_3$ 36.64. | H_2O 47.12. |
| 18. | Na 21.24. $B(OH)_3$ 47.94. | H_2O 30.82. |
| 19. | a. 122.8 cwt., borax; 34.07 cwt., Na_2CO_3 .
b. 81.86 Kg, borax; 22.71 Kg, Na_2CO_3 . | |
| 20. | a. 144.56 g. b. 28.91 lbs. | |
| 21. | NaCl. a. 60.68 Cl.; 39.32 Na. b. 100 Na.; 154.35 Cl.
c. 100 Cl.; 64.79 Na. | |

AMMONIUM.

1. 2 : 4 : 2 or 1 : 2 : 1. 200 : 34 : 2 or 100 : 17 : 1.
2. a. 123.36 cwt.; 109.34 cwt. b. 98.69 g; 87.47 g. c. 12.34 lbs.; 10.93 lbs. d. 4.934 g; 4.37 g.
3. 89.72 lbs. $(NH_4)_2CO_3$; 160.74 lbs. gypsum; 132.71 Na_2SO_4 .
4. 100 g, $(NH_4)_2CO_3$; 61.86 HCl.
5. 110.3 and 341.1 lbs.
6. 2 per cent.
7. 3.5 per cent.

BARIUM.

- | | BaS. | $Ba(OH)_2$ | $BaNO_3$. | $BaCl_2$. |
|----|---|---|---|--|
| 1. | a. 169 lbs.,
b. 84.5 g,
c. 72.53 g,
d. 725.32 g, | 171 lbs.,
85.5 g,
73.39 g,
733.9 lbs., | 261 lbs.,
130.5 g,
112.02 g,
1120.2 g, | 208 lbs.
104 g.
89.27 g.
892.7 g, |

- | | | |
|-----|---|---|
| | C. | CO ₂ . |
| 2. | a. 48 lbs.,
b. 24 g,
c. 20.61 g,
d. 206 g, | 112 lbs.
56 g.
48.07 g.
480 g. |
| | Heavy Spar. | C. |
| 3. | a. 116.5 g,
b. 53 g,
c. 280 g,
d. 112.02 lbs., | 24 g.
10.9 g.
57.7 g.
23.68 lbs. |
| | BaSO ₄ . | K ₂ CO ₃ . |
| 4. | a. 233 g,
b. 116.5 lbs.,
c. 118.27 lbs.,
d. 1 Kg 182.7 g, | 138 lbs.
69 lbs.
70.05 lbs.
700.5 g. |
| 5. | 10 g. | |
| 6. | 10.01 per cent. | |
| 7. | (5) 3.51 g, HCl.
(6) 1.965 g, HCl. | |
| 8. | 5 per cent. | |
| 9. | 1.125 (NH ₄) ₂ O. 2.077 (NH ₄) ₂ CO ₃ . | |
| | Na ₂ CO ₃ . | BaCl ₂ . |
| 10. | a. 29.0 g,
b. 725.89 g,
c. 1 Kg 451.8 g, | 21.1 g.
527.9 g.
1 Kg 55.8 g. |
| 11. | a. 11.88 g, salt. b. 296.9 g, salt. c. 593.91 g, salt. | |

CALCIUM.

1. a. 56 lbs. b. 560 Kg. c. 0.56 lbs. d. 14 g.
2. a. 74 lbs. b. 740 Kg. c. 0.74 lbs. d. 18.5 g.
3. a. 100 lbs. b. 25 cwt. c. 250 Kg. d. 178.57 lbs. e. 1785.71 Kg.
f. 892.85 lbs.
4. a. 11.16 cu m. b. 279 cu m. c. 55.8 cu m. d. 19.93 cu m.
e. 398.6 cu m. f. 99.6 cu m.
5. a. 18 lbs. b. 4½ cwt. c. 45 Kg. d. 32.14 lbs. e. 321.428 Kg.
f. 160.7 lbs.
6. a. 11.16 cu m. b. 19.94 cu m. c. 39.86 cu m. d. 558 cu m.

- | | | | |
|-----|---|----------------------------------|---|
| | CaCl ₂ . | | Na ₂ CO ₃ . |
| 7. | a. 44.4 g,
b. 1 Kg 110 Kg,
c. 111 g,
d. 5.55 lbs., | | 42.4 g.
1 Kg 60 g.
106 g.
5.3 lbs. |
| | Lime. | H ₂ SO ₄ . | H ₂ O. |
| 8. | a. 32.56,
b. 41.17, | 46.54,
58.83. | 20.93. |
| 9. | a. 18 lbs. | b. 4.5 g. | c. 264.7 g. d. 13.23 g. |
| 10. | a. 234 g. | b. 82.39 lbs. | c. 1 Kg 648 g. |
| 11. | | | |
| | Cl. | | Limestone. |
| 12. | a. 142 lbs.,
b. 71 g,
c. 13.97 g,
d. 55.9 Kg, | | 112 lbs.
56 g.
11.02 g.
44.1 Kg. |
| 13. | a. 44.61 l. | b. 8.787 cu m. | c. 17.57 cu m. |
| | HCl. | | MnO ₄ . |
| 14. | a. 292 lbs.,
b. 146 g,
c. 28.73 g,
d. 114.9 Kg, | | 174 lbs.
87 g.
17.12 g.
68.5 Kg. |
| 15. | a. 858.93 lbs. | b. 428.87 lbs. | c. 2399.06 lbs. |
| 16. | a. 24.66 Kg. | b. 165.5 Kg. | c. 84.97 Kg. |
| 17. | a. 1.4 g. | b. 2.775 g. | c. 3.4 g. |
| 18. | a. 18.666 per cent. | b. 37 per cent. | c. 45.33 per cent. |

MAGNESIUM.

1. 341.46 Kg.

2. ———

- | | | | |
|----|--|---------------|---|
| | MgS. | | K ₂ CO ₃ . |
| 3. | a. 492 g,
b. 123 lbs.,
c. 300 lbs.,
d. 3000 Kg, | | 276 g.
69 lbs.
168.3 lbs.
1682.9 Kg. |
| 4. | a. 45 g. | b. 11.25 lbs. | c. 27.4 lbs. d. 274.4 Kg. |
| 5. | a. 41 lbs. | b. 8.2 g. | c. 205 lbs. d. 2050 g. |
| | NH ₃ . | MgO. | P ₂ O ₅ . |
| 6. | a. 6.94,
b. 45.31 per cent. | 16.33, | 28.98,
47.75. |

7. *a.* 0.4 g. *b.* 1.33 g. *c.* 0.9 g.
(P_2O_5) ($2 N_2O, P_2O_5$)
8. *a.* 31.555 per cent., 59.1 per cent.
b. 52.59 per cent., 98.5 per cent.
c. 10.518 per cent., 19.70 per cent.
d. 2.104 per cent., 3.94 per cent.

ALUMINUM.

1. (1) *a.* 10.83 per cent. *b.* 36.13 per cent.
(2) *a.* 11.21 per cent. *b.* 37.39 per cent.
(3) *a.* 11.34 per cent. *b.* 37.80 per cent.
2. (1) *a.* 45.53 per cent. *b.* 54.47 per cent.
(2) *a.* 47.10 per cent. *b.* 52.90 per cent.
(3) 47.64 per cent. 37.80 per cent. 11.34 per cent.
- | | Alum. | K_2CO_3 . | CO_2 . |
|-----------------|-------------|-------------|------------|
| 3.—4. <i>a.</i> | 948.8 g, | 414 g, | 132 g. |
| <i>b.</i> | 237.2 lbs., | 103.5 lbs., | 33 lbs. |
| <i>c.</i> | 92.29 lbs., | 40.27 lbs., | 12.84 lbs. |
| <i>d.</i> | 9.23 Kg, | 403 Kg, | 1.28 Kg. |

IRON.

1. *a.* 72.41 per cent. *b.* 70.03 per cent. *c.* 59.89 per cent.
d. 48.27 per cent.
2. *a.* 304 g. *b.* 7.6 g. *c.* 1.9 lbs. *d.* 38 g.
3. *a.* 56 g. *b.* 0.5989 g. *c.* 5.6 g. *d.* 0.599 g.
4. *a.* 0.718 g. *b.* 3.59 g. *c.* 5.384 lbs. *d.* 28.72 g.
5. (1) *a.* 14.23; *b.* 18.30; *c.* 38.64; *d.* 29.49.
(2) *a.* 4.74; *b.* 6.10; *c.* 12.88; *d.* 9.83.
6. *a.* 139 cwt. *b.* 2316.67 lbs. *c.* 69.5 Kg. *d.* 231.67 Kg.
7. *a.* 1946 lbs. *b.* 300.31 cwt. *c.* 3003.086 Kg. *d.* 180.185 lbs.
- | | Oxygen. | Water. |
|--------------|--------------|------------|
| 8. <i>a.</i> | 1116.1 cu m, | 63 cwt. |
| <i>b.</i> | 186.0 cu m, | 1050 lbs. |
| <i>c.</i> | 11.16 cu m, | 31.5 Kg. |
| <i>d.</i> | 37.20 cu m, | 105 Kg. |
| | O. | H_2O . |
| 9. <i>a.</i> | 156.25 cu m, | 882 lbs. |
| <i>c.</i> | 482.25 cu m, | 1361.1 Kg. |

10. a. 16 cwt. b. 266.67 lbs. c. 8 Kg. d. 26.67 Kg.
11. a. 278 lbs. b. 139 g. c. 1390 g. d. 695 lbs.
12. $\frac{1}{2}$.
13. a. 315 parts. b. 157.5 parts.
14. K_2SO_4 . FeSO_4 .
 a. 87 g, 200 g.
 b. 3.457 g, 7.952 g.
 c. 0.173 lbs., 0.397 lbs.
15. ———
16. ———
17. Fe. K_2CO_3 .
 a. 28 g, 138 g.
 b. 13.27 lbs., 65.4 lbs.
 c. 132.7 Kg, 654 Kg,
18. FeCy_2 . Fe_2Cl_6 .
 a. 1106 g, 650 g.
 b. 55.3 lbs., 32.5 lbs.
 c. 128.6 lbs., 75.58 lbs.
 d. 1286.05 Kg, 755.81 Kg.
19. FeCy_2 . FeSO_4 .
 a. 162 g, 152 g.
 b. 40.5 lbs., 38 lbs.
 c. 87.85 g, 82.43 g.
 d. 486 lbs., 456 lbs.
20. FeCy_2 . Fe_2O_3 .
 a. 972 g, 160 g.
 b. 243 g, 40 g.
 c. 113.02 g, 18.60 g.
 d. 1130.23 lbs., 186.04 lbs.
21. FeCy_2 . FeSO_4 .
 a. 553.2 lbs., 456 lbs.
 b. 128.65 lbs., 106.05 lbs.
 c. 1286.5 cwt., 1060.46 cwt.
 d. 643.25 Kg, 530.23 Kg.
22. a. 11.16 cu dm. b. 0.529 cu dm. c. 66.11 cu dm.
23. a. 329 g. b. 15.59 g. c. 19.49 Kg.
24. a. 422 g. b. 13.21 lbs. c. 32.07 g. d. 1 Kg 283 g.

MANGANESE.

- a. 88 g. b. 4.4 g. c. 2.2 lbs. d. 10.115 g.
2. a. 67.6 per cent. b. 75.6 per cent. c. 90.7 per cent.
d. 37.8 per cent.
3. a. 63.4 g. b. 2.11 g. c. 1.46 g.
4. a. 68.61 per cent. b. 34.30 per cent. c. 90.05 per cent.
d. 54.03 per cent.

CHROMIUM.

1. ———
2. a. 200 g. b. 131.58 g. c. 131 lbs. d. 1 Kg 315 g.
3. a. 294 g. b. 193.42 g. c. 1.93 lbs. d. 1 Kg 934.2 g.
4. Cr-iron. K_2CO_3 .
a. 224 g, 276 g.
b. 100 lbs., 123.2 lbs.
c. 76.2 lbs., 93.9 lbs.
d. 761.90 g, 938.8 g.
- K_2CrO_4 . H_2SO_4 . H_2O .
5. a. 294 g, 392 g, 360 g.
b. 29.46 lbs. 39.28 lbs., 36.07 lbs.
c. 7.36 g, 9.82 g, 9.02 g.
6. a. 388 g. b. 76.58 g. c. 255.26 g. d. 2.55 lbs.
- K_2CrO_4 . NH_4Cl . K_2CO_3 .
7. a. 294 g, 214 g, 138 g.
b. 96.71 g, 70.39 g, 45.39 g.
c. 1.93 lbs., 1.41 lbs., 0.91 lbs.
- K_2CrO_4 . $Pb, C_4H_8O_4$.
8. a. 194 g, 379 g.
b. 6.01 lbs., 11.73 lbs.
c. 30 g, 58.7 g.
d. 600.6 g, 1 Kg 173.4 g.
9. a. 8.84 per cent. b. 20.51 per cent.
10. a. 49 g. b. 24.5 lbs. c. 2.52 g. d. 6.31 g.

ZINC.

1. a. 67.01 per cent. b. 52 per cent.
2. a. 4.514 cu cm. b. 0.564 cu cm. c. 1.114 cu cm.
3. a. 32.5 g. b. 8.125 lbs. c. 4.0625 g. d. 8.024 g.

4. a. 143 g. b. 35.75 lbs. c. 17.875 g. d. 35.31 g.
 White Vitriol. CaCl.
 5. a. 161 g. 111 g.
 b. 11.84 g. 8.16 g.
 c. 591.91 g. 408.09 g.
 6. a. 45.1 cu cm. b. 22.57 cu cm. c. 0.825 cu cm. d. 41.22 cu cm.
 7. a. 30.35 per cent. b. 37.83 per cent. c. 63.52 per cent.
 d. 75.20 per cent. e. 58.39 per cent.

COPPER.

1. a. 187.4 g. b. 93.7 lbs. c. 236.02 g. d. 23.60 lbs.
 2. a. 241.4 g. b. 120.7 lbs. c. 304.03 g. d. 30.40 lbs.
 3. Same as (2).
 CuSO₄. Na₂CO₃.
 4. a. 249.4 g. 286 g.
 b. 124.7 lbs., 143 lbs.
 c. 314.106 g. 360.20 g.
 d. 31.41 lbs., 36.02 lbs.
 5. a. 63 g. b. 31.7 g. c. 100 lbs. d. 50 g. e. 10 lbs.
 6. a. 31.7 lbs. b. 100 g. c. 79.83 g. d. 4 g.
 7. (1) a. 79.4 g. b. 12.5237 g. c. 6.26 lbs. d. 62.618 g.
 (2) a. 142.8 g. b. 22.5237 g. c. 11.26 lbs. d. 112.618 g.
 8. a. 5.58 cu dm. b. 7.815 cu dm. c. 5 cu dm.
 9. a. 5.58 cu dm. b. 7.815 cu dm.
 10. (1) a. 5.58 cu dm. b. 7.815 cu dm.
 (2) a. 31.7 g. b. 44.4 g.
 11. a. 159.4 lbs. b. 100.38 lbs. c. 1003.78 Kg. d. 501.89 lbs.
 12. a. 318.8 lbs. b. 200.76 lbs. c. 2007.56 Kg. d. 1003.78 lbs.
 13. 23.56 per cent.
 14. a. 41.76 lbs. b. 4.176 Kg. c. 20.88 g. d. 0.04176 g.
 15. a. 183.11 lbs. b. 18.311 Kg. c. 91.55 g. d. 0.18311 g.
 16. a. 235.58 lbs. b. 11.78 Kg. c. 1177.9 Kg. d. 235.58 cwt.
 17. a. 88.78 per cent. b. 79.85 per cent. c. 34.57 per cent.
 d. 55.58 per cent. e. 57.43 per cent. f. 55.26 per cent.
 18. a. 691.4 g. b. 1728.5 lbs.
 19. a. 14.36 cwt. b. 143.6 Kg. c. 2871.5 lbs. d. 143.6 cwt.

20. a. 71.61 per cent. b. 84.25 per cent. c. 80 per cent.
d. 90 per cent.
21. a. 11.234 per cent. b. 14.0428 per cent.
22. a. 672 g. b. 6.72 g. c. 90.81 g. d. 268.8 g.

MERCURY.

- | | | | |
|----|---|--|---|
| | Hg ₂ Cl ₂ . | | Hg. |
| 1. | a. 271 g,
b. 54.2 g,
c. 1 Kg 726.1 g,
d. 32.2 lbs., | | 200 g.
40 g.
1 Kg 273.9 g.
23.8 lbs. |
| | HgSO ₄ . | Hg. | NaCl. |
| 2. | a. 296 g,
b. 9.866 lbs.,
c. 3.14225 lbs.,
d. 6.285 g, | 200 g,
6.666 lbs.,
2.1231 lbs.,
4.2462 g, | 117 g.
3.9 lbs.
1.2420 lbs.
2.484 g. |
| | HgSO ₄ . | | NaCl. |
| 3. | a. 148 g,
b. 59.2 g,
c. 109.225 g, | | 58.5 g.
23.4 g.
43.17 g. |
| 4. | a. 100 g. b. 2.952 lbs. c. 7 Kg 380 g. d. 73.80 g. | | |
| 5. | a. 531 $\frac{2}{3}$ lbs. b. 2416 $\frac{2}{3}$ lbs. c. 4833.33 Kg. d. 483 $\frac{1}{3}$ cwt. | | |
| 6. | a. 6.77 per cent. b. 15.24 per cent. c. 19.65 per cent. | | |
| 7. | a. 12 g. b. 69.44 g. | | |
| 8. | 11 : 14. | | |

LEAD.

1. a. 331 g. b. 148.43 g. c. 7.421 lbs.
2. a. 207 g. b. 92.82 g. c. 4.6412 lbs.
3. (1) a. 11.16 cu dm. b. 5.0 cu dm. c. 125.1 cu dm.
(2) a. 53.1 cu dm. b. 23.8 cu dm. c. 596.7 cu dm.
4. a. 908 g. b. 151.61 lbs. c. 50.52 g. d. 3.8 lbs.
5. a. 16 g. b. 3.2 lbs. c. 2.335 g. d. 11.68 g.
6. a. 621 lbs. b. 80.13 lbs. c. 801.29 cwt. d. 8 Kg 12.9 g.
7. a. 22.32 cu m. b. 2.88 cu m. c. 2880.17 cu m. d. 0.576 cu m.
8. a. 446 lbs. b. 1.1765 lbs. c. 29.4 g. d. 223 g.
9. _____
10. _____

11. $\frac{3}{5}$.
 12. a. 772.3 Kg. b. 77.23 lbs.
 13. a. 2007 lbs. b. 1000 lbs. c. 100 Kg. d. 1294.8 Kg.
 14. a. 86.61 per cent. b. 77.53 per cent. c. 68.31 per cent.
 15. a. 2.56 lbs. b. 2565 lbs. c. 256.57 Kg. d. 10263 Kg.
 16. a. 66.6 per cent. b. 50 per cent. c. 70 per cent.

SILVER.

1. 63.53 per cent.
 2. a. 216 g. b. 0.6353 g. c. 3.176 g. d. 63.53 g.
 3. 23.66 g.
 4. $\text{Cu}(\text{NO}_3)_2$. Ag_2O .
 211.53 g. 787.03 g.
 5. a. 12.70. b. 63.51. c. 10.
 6. a. 0.913 g. b. 2.6018 g. c. 1.4635 g.
 7. a. 13.87 per cent. b. 8.654 per cent.
 8. a. 12.85 g. b. 4.98 g.
 9. 80 per cent.
 10. 1076.22 lbs.
 11.

Au.	Ag.	CuSO_4 .	Cu.
a. 3 g.	b. 1350 g.	c. 2137.01 g.	d. 396.25 g.

 12.

Au.	Ag.	CuSO_4 .	Cu.
a. 0.3 g,	135 g,	213.70 g,	39.625 g.
b. 0.4 g,	180 g,	284.93 g,	52.83 g.
c. .06 g,	27 g,	42.54 g,	7.925 g.

 13. a. 340 g. b. 53.62 g. c. 26.81 g. d. 13.40 g.
 14. a. 28.7 g. b. 1.435 g. c. 0.205 g. d. 4.1 g.

TIN.

1.

Sn.	HCl.
a. 118 lbs.,	73 lbs.
b. 39.33 Kg,	24.33 Kg.
c. 2.622 g,	1.622 g.
d. 52.44 g,	32.44 g.
e. $52\frac{4}{9}$ lbs.,	$32\frac{4}{9}$ lbs.

ANSWERS TO PROBLEMS.

105

2. a. 219 lbs. b. 73 Kg. c. 4.87 g. d. 97.33 g. e. $97\frac{1}{3}$ lbs.
3. a. 44.64 cu dm. b. 1.116 cu dm. c. 2.232 cu dm. d. 1.891 cu dm.
MnO₂. HCl.
4. a. 174 g, 292 g.
b. 4.35 g, 7.3 g,
c. 8.7 g, 14.6 g,
d. 7.37 g, 12.37 g,
5. a. 14124.2 lbs. b. 141242.2 cwt. c. 70621.4 Kg.
6. a. 50 per cent. b. 25 per cent.
7. 20.878 per cent.

ANTIMONY.

1. a. 23.62 per cent. b. 24.76 per cent.
2. a. 340 g. b. 42.5 g. c. 8.5 lbs. d. 0.8416 g.
SbCl₃. Na₂CO₃. NaCl. CO₂.
3. a. 457 g, 318 g, 351 g, 132 g.
b. 22.85 g, 15.9 g, 17.55 g, 6.60 g.
c. 1.56 lbs., 1.09 lbs., 1.20 lbs., 0.45 lbs.
4. Sb₂S₃Na₃. HCl.
a. 962 g, 1095 g.
b. 24.05 lbs., 27.375 lbs.
c. 2.38 g, 2.71 g.
d. 238.12 g, 271.04 g.
5. a. 321 g. b. 8.025 lbs. c. 0.79 g. d. 79.45 g.
6. 71.76 per cent.
7. 1 : 2.

ARSENIC.

1. S. As.
a. 64 g, 150 g.
b. 32 lbs., 75 lbs.
c. 29.91 lbs., 70.09 lbs.
d. 299.06 g, 700.93 g.
 2. S. As.
a. 96 g, 150 g.
b. 48 lbs., 75 lbs.
c. 16 g, 25 g.
d. 390.24 g, 609.76 g.
 3. a. 0.99 g. b. 3.30 g. c. 1.98 g. d. 2.4235 g.
 4. a. 3.75 per cent. b. 0.052 per cent. c. 0.649 per cent.
- H

PLATINUM.

1. 39.27 per cent.
2. *a.* 0.254 g. *b.* 3.838 g.
3. *a.* 0.945 g. *b.* 1.709 g.
4. 13.59 per cent.

PART SECOND.

APPROXIMATE RATIOS.

1. 2 : 3.
2. 7 : 12.
3. 9 : 10.
4. 1 : 4.
5. 9 : 22.
6. 12 : 5 : 2.
7. 13 : 7.
8. 5 : 3.
9. 3 : 2.
10. 4 : 3 : 5.

TEMPERATURE AND ATMOSPHERIC PRESSURE.

1. 0.29133 cu m.
2. 83663 cu cm.
3. 4319.4 l.
4. 1068.4 l.
5. 10.042 acid; 17.325 air.
6. 4.651 per cent.
7. 230.6 Kg.
8. 214.22 cu dm.

MIXED PROBLEMS.

1. 360 days.
2. $\text{H}_2\text{SO}_4 = 457 \text{ d}$; $\text{Zn} = 480 \text{ days}$.
3. 113.8 g, H_2SO_4 . 75.48 g, Zn. 47.42 g, K_2CO_3 .
4. 44.5 Kg, marble. 47.61 Kg, H_2SO_4 .

5. 500 l, H_2O . 22 Kg, 400 g, CaCO_3 . 21 Kg, 952 g, H_2SO_4 .
6. 36.5 g.
7. 2.1 mm.
8. a. 4 l, H_2O . b. 43.904 g, H_2SO_4 . c. 39.424 g, FeS .
9. 9.962 l, H_2O . 0.0983 Kg, FeS . 0.1095 Kg, H_2SO_4 .
10. 0.06896 per cent.
11. 0.0525 g.
12. 0.00297 g, C.
13. ———
14. 18.25 per cent.
15. 21.368 per cent.
16. a. 0.0065. b. 0.0107.
17. 0.0136.
18. 93.3 per cent.
19. a. 0.1346 per cent. b. 0.226 per cent. c. 0.817 per cent.
20. a. 0.2218 per cent. b. 0.2994 per cent. c. 0.2024 per cent.
21. 93.16 per cent.
22. For carbonate 16.66. For phosphate 66.61.
23. 10.08 per cent.
24. 35 Kg.
25. 47.3 g, K, and 15.4 g, Na.
26. 27.73 per cent., K. 8.81 per cent., Na.
27. 20.36 per cent., K_2CO_3 . 7.53 per cent., Na_2CO_3 .
28. K $\frac{5}{7}$ of Na.
29. 11 Kg of latter less than 5.3 Kg of former.
30. \$5.15 cts. +.
31. 152.9 cu dm, Cu. 16719.4 Kg, Vitriol sol.
32. \$16.00 +.
33. 0.834 Ag (or 83.4 per cent.).
34. 327.7 lbs.
35. a. 33.396 lbs. b. 74.382 lbs.
36. a. 55.407 lbs. b. 123.12 lbs.
37. 11.63 Kg.

38. 50.8 g. NaCl. 43.07 H_2SO_4 .
39. 12 per cent.
40. 42.97 Kg.
41. 14.10 lbs.
42. 332.25 lbs., saltpeter. 347.11 lbs., H_2SO_4 .
43. a. 213.33 Kg, lime; 525.71 Kg, KCO_3 . b. 600.2 KNO_3 .
44. 34.47 g, Zn. 61.25 g. H_2SO_4 .
45. 33.84 g, Zn. 158.5 g, HCl.
46. 745.15 g, vitriol. 90.59 g, iron.
47. 386.93 Kg, Eng. H_2SO_4 . 709.409 Kg, bye-product.
48. 1592.8 Kg, N substance. 120.8 Kg, Fe. 667.7 Kg, potash.
49. 18.53 g.
50. 50.22 g, H_2SO_4 . 3.09 g, C.
51. 17.9 per cent., dead burnt. a. 28.6 per cent., H_2O . b. 26.4 per cent., H_2O .
52.
$$\begin{array}{r} 73.895 \\ 11.812 \\ \hline 14.293 \\ 100.000 \end{array}$$
53. 1.294 lbs., PbO. 0.252 lbs., H_2SO_4 . 0.258 lbs., CaCO_3 .
54. (1) a. 1.33 lbs., Cu. b. 1.17 lbs., Fe. c. 5.80 lbs., vitriol.
(2) 1.34 lbs., Zn.
55. 3.43 g, BaS. 2.15 g, Na_2CO_3 . 2.81 g, K_2CO_3 .
56. 77.28 g.
57. 489.5 cwt.
58. 6.93 Kg.
59. 146.2 g.
60. 47.1 g, calomel.
61. 325.9 g.
62. 262 Kg.
63. 582.7 Kg.
64. 21.2 g.
65. 18.27 g.
66. 17.55 g, BaS. 13.10 g, K.

67. $\text{K}_2\text{O}, 2 \text{CrO}_3 + \text{H}_2\text{SO}_4 + 3 \text{SO}_2 =$
 $\text{K}_2\text{SO}_4 + \text{Cr}_2(\text{SO}_4)_3 + \text{H}_2\text{O}.$
68. (1) 386.6.
 (2) $3 (\text{CaO}, \text{CO}_2) + 6 \text{NH}_4\text{Cl} =$
 $3 \text{CaCl}_2 + 2 (\text{NH}_4)_2\text{O}, 3 \text{CO}_2 + 2 \text{NH}_3 + \text{H}_2\text{O}.$
69. 4.89 g.
70. (1) $12 \text{I} + 6 \text{K}_2\text{O} = 10 \text{KI} + \text{K}_2\text{O}, \text{I}_2\text{O}_5.$
 (2) 130.7 g.
 (3) 6.3 g, O.
71. 27.0 lbs.
72. 200 cwt.
73. 4.23 per cent., I. 1.48 per cent., MnO_2 . 16.43 per cent., HCl.
74. 88.6 per cent.
75. 7.763 Kg, Hg.
76. \$6.00.
77. 46.08 g.
78. 52.767 NaCl. 47.233 KCl.
79. 1.473 lbs., K salts. 2.066 lbs., H_2SO_4 . 0.813 lbs., alcohol.
80. 9.12 dg.
81. a. b. c. 56.
82. a. b. c. 108.
83. $\text{CaO}, \text{MgO}, 2 \text{CO}_2.$
84. ———
85.

FeO.....	38.02
Fe ₂ O ₃	61.98
	100.00
86. ———
87. $4 \text{FeO}, 3 \text{Fe}_2\text{O}_3.$
88. $\text{Al}_2\text{O}_3, 3 \text{SO}_3 + 18 \text{H}_2\text{O}.$
89. $\text{K}_2\text{O}, \text{Al}_2\text{O}_3, 6 \text{SiO}_2.$
90. 4.52 per cent.
91.

a. Combustible sub.....	52.68
Ashes.....	5.76
Water	41.56
	100.00

92. Sugar..... 95.00
 Water..... 2.20
 Ashes..... 1.32
 Foreign organ. sub..... 1.48
100.00
93. In 100 parts :— H_2O 2.48. K 25.26. H_2SO_4 31.49.
 Or,
 H_2O 2.48
 K_2SO_4 46.76
 Na_2SO_4 17.75
 Foreign sub..... 33.01
100.00
94. 100000 parts :—
 Min. sub..... 59.70
 Org. sub..... 9.60
69.30
 Or from this :— SiO_2 0.12. Fe_2O_3 + 0.21. CaO 30.77.
 Mg .466. H_2SO_4 5.27. KCl 1.07. Cl .65.
95. 100000 parts :—
 SiO_2 0.12
 Fe_2O_3 +..... 0.21
 $CaCO_3$ 48.26
 $CaSO_4$ 8.96
 $MgSO_4$99
 NaCl 1.07
59.71
96. In 100 parts :—
 $CuCO_3$ 93.57
 $MgCO_3$ 1.13
 Fe_2O_3 +..... .75
 $CaSO_4$94
 $CaCl_2$ 0.06
 Sand and Clay..... 3.55
100.00
97. Factors :—
a. 0.83562. *b.* 0.80488. *c.* 0.65665. *d.* 0.34335. *e.* 0.77665.
f. 0.92825. *g.* 0.68317. *h.* 0.93305. *i.* 0.56000.
98. Factors :—
a. 0.70000. *b.* 0.90000. *c.* 0.44000. *d.* 0.79849. *e.* 0.36036.
f. 0.63964. *g.* 0.13734. *h.* 0.11111. *i.* 0.80260. *k.* 0.78667.
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100. 0.50.
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INDEX OF SUBJECTS.

	PAGE
CHEMISTRY AND PHYSICS,	3
TECHNOLOGICAL AND MANUFACTURERS' BOOKS, ETC.,	5
PHARMACY AND BOTANY,	6
MEDICAL LEXICONS,	9
THE MICROSCOPE,	10
DYSPEPSIA, HEALTH, HAY FEVER, HEADACHES, ETC.,	11
MISCELLANEOUS,	12
HOSPITALS AND MANUALS OF NURSING,	14
HYGIENE,	14
THE CARE OF CHILDREN,	16
HEALTH RESORTS,	16

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